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FRIDAY, DECEMBER 7, 1900.

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THE HISTORY OF THE NEOTROPICAL REGION.

IN No. 276 of SCIENCE, April, 1900, Dr. Henry F. Osborn published an article on the 'Geological and Faunal Relations of Europe and America during the Tertiary Period,' to which I may here refer, as it may be useful for science to discuss the different opinions to which our study has led us.

It is singular that Mr. Osborn has no knowledge at all of the numerous papers published by the writer on the history of the neotropical fauna, and consequently it is necessary to say at first some words on these papers, and the new discoveries and ideas published in them. Referring here only to those of my publications in which the geological and zoogeographical relations of South America were fully discussed, I name the following:

1. 'Die Geographische Verbreitung der Flussmuscheln.' *Das Ausland*, Stuttgart, 1890, Nos. 48–49; and translated 'The Geographical Distribution of the Freshwater Mussels.' The New Zealand *Journal of Science*, Vol. I., Dunedin, 1891, pp. 151-154.

2. 'Ueber die Beziehungen der chilenischen und suedbrasilianischen Suesswasser fauna.' *Verhandlungen des deutschen wissenschaftlichen Vereines zu Santiago*, Vol. II., 1891, p. 142–19.

3. 'Ueber die alten Beziehungen zwischen Neuseeland und Suedamerika.' *Ausland*, Stuttgart, 1891, No. 18. Translated, 'On

the Ancient Relations between New Zealand South America.' *Transactions* of the New Zealand Institute, Vol. XXIV., 1891, p. 431–445.

4. 'Die Palaeo-Geographie Suedamerikas.' *Ausland*, Stuttgart, 1893, Nos. 1–4.

5. 'Revision der von Spix in Brasilien gesammelten Najaden.' *Archiv. für Naturgeschichte*, 1890, p. 117–170, Taf. IX.

6. 'Najaden von S. Paulo und die geographische Verbreitung der Suesswasserfaunen von Suedamerika.' *Archiv. für Naturgeschichte*, 1893, pp. 45–140, Taf. III.–IV.

7. 'Das neotropische Florengebiet und seine Geschichte.' *Engler's Botanische Jahrbücher*, Vol. XVII., 1893, pp. 1–54.

8. 'Die Ameisen von Rio Grande do Sul.' *Berliner entomologische Zeitschrift*, Band 39, 1894, pp. 321–446.

9. 'Os molluscos dos terrenos terciarios da Patagonia.' *Revista do Museu Paulista*, Vol. II., 1898, pp. 217–382, Pl. III.–IX., with Conclusions in English, pp. 372–380.

The study of the fresh water fauna, and especially of the Unionidæ of South America, gave me as a practical result the separation of two sub-regions 'Archiplata' and 'Archamazonia.' The first contains Chili, Argentina, Uraguay and Southern Brazil, the second Central and Northern Brazil (Archibrazil) and Guyana, Venezuela, etc. (Archiguyana). Archiplata contains numerous genera of Mollusca, Crustacea, etc., that are common to Chili and the La Plata district, such as *Unio*, *Chilina*, *Parastacus*, *Aeglea*, etc., including many species and even their parasites (*Temnocephala*), which are identical on both sides of the Andes. This contrasts sharply with the Archamazonian fauna, as tropical genera extend to Rio Plata and Rio Negro which are completely wanting in Chili and Peru. In Ecuador, however, the Cordillere form no such zoogeographical division, due certainly to differences in the geological history of both parts of the Andes. For example the Decapod Crustacea in Chili and in the whole of Archiplata are the Parastacidæ and Aegleidæ, but the Potamoninæ are in Archamazonia. Dr. Ortmann has opposed to my explanations the hypothesis that biological differences may be the true reason, exterminating the Potamoninæ that invaded Archiplata, but favoring the Parastacidæ. The observations made by the writer on the biology of these Crustacea emphatically annul the objection. In Northern Argentine, Rio Grande do Sul and St. Catherina, both coexist in the same waters and while the Potamonidæ prefer rivers and brooks, living among aquatic plants, the *Parastacus* selects muddy territory where it can burrow.

That the explanation is a geographical one is proved also by the fact that the species of Unionidæ, Mutelidæ, Ampullariidæ, etc., which occur in the La Plata and in the Rio Paraguay, are almost all Amazonic species. Moreover the faunal relations of the Paraná River are totally different from those of the Paraguay River. In confirmation of these zoogeographical facts the geological ones indicate to us in the Entrerian-formation Unio of the Niæa group, Chilina, Strophocheilus, etc., that is to say, the pure Archiplata fauna. These facts point out that the invasion of the Archamazonian element into Archiplata is quite a recent one. The intrusion of the Archamazonian element is Pliocene or post-Tertiary, and the Andes formed a barrier insurmountable to fresh-water crabs and mussels as well as to fishes, chelonians and alligators.

It is evident that the two faunal elements of South America correspond to geographical districts which were separated by the ocean during the greater part of the Tertiary. The intermixture of the two elements, and especially the intrusion of Bolivian ants, land snails, etc., in Eastern Brazil is by no means finished, but is a fact which

we observe to-day. It is highly probable that these conditions, which are decisive not only for the fresh-water fauna but also for the land gastropods, have determined also the history of the mammals, which may have reached Brazil only in the Pliocene.

Although these inferences concerning the different faunal elements of the neotropical fauna, based on the zoogeographical work of the writer, seem to be quite conclusive, the matter is more difficult and hypothetical if we turn to the ancient relations of Archiplata and Archamazonia to other regions of the globe.

The connection of Archiplata with a great antarctic continent during the Cretaceous and Eocene formation seems now to be generally accepted, but the historic data given on the matter by Osborn are very incomplete. The first to discuss the question was the eminent botanist, Sir William Hooker, but the work of Wallace, and especially his axiom of the permanence of the great oceanic depths, for a long time retarded further progress. Not until 1883 did Hutton, with reference to New Zealand, and in 1890 the writer, with reference to Archiplata, turn aside to publish new facts in favor of the hypothesis of Hooker, which was also confirmed by Fl. Ameghino.

In relation to the ancient connection of Africa and Archamazonia I have given arguments (1890) in favor of a Mesozoic 'archiatlantic continent,' which existed during the earlier Tertiary. At first because of some paleontological facts noted by Schlosser, I believed that this continent could have transmitted Eocene mammals from South Africa to Europe, an idea now defended by Ameghino and Osborn; but in 1893 I modified my opinion and set forth the hypothesis that no Eocene placental mammals had existed either in Archamazonia or in Æthiopian Africa. The ancient continent uniting Archamazonia with America I named Archiatlantica in 1890, using in 1892 the term Helenis, and in 1893 that of Archhelenis, with the purpose of preventing confusion with the 'Atlantis' a hypothetical land bridge between South Europe and Central America proposed by Unger.

I will not repeat here what I have said elsewhere as to the intimate relation between the fresh water faunas of Brazil, Guiana, and of equatorial Africa, but I shall make some remarks on the geographical distribution of the fresh-water mussels. North America agrees in its Unionidæ with Eurasia, the genera *Unio*, *Margaritana* and *Anodonta* being predominant. The archiplatic element of South America is formed only by the genus *Unio*, and by a section of it which has no representatives in the holarctic region, forming the subgenus *Niæa*, which is found also in New Zealand and Australia. The numerous presumed genera of *Unio* now admitted in North America all agree in the characteristic sculpture of the beaks, which is quite different in *Niæa*. I consider, therefore, *Niæa* as a genus and the North American sections of *Unio* only as subgenera. In the archhelenic region we have representatives of *Unio* which are more intimately allied to *Niæa* than to *Unio*, no Anodontas, but very numerous representatives of the Mutelidæ. The South American 'Anodonta' are all *Glabaris*, a genus of Mutelidæ allied to *Spatha* of Africa.

Considering the geological history, we find the precursors of the actual North American Unionidæ as far back as the Jurassic period, and what we know of fossil mussels of New Zealand and Archiplata are only *Unios* of the *Niæa* section. On the other hand, Cretaceous deposits of Bahia show us representatives of *Glabaris* and *Mycetopus*. The actual conditions of distribution therefore predominated even in the Mesozoic time, and no explanation can be given of the intimate relation be-

tween the fresh-water faunas of tropical Africa and South America than the hypothesis of an ancient land bridge; supposing that these faunas were only the remains of an ancient cosmopolitan tropical fauna, the paleontological evidence should be totally different.

In regard to the geological distribution of the mammals of South America, the opinions of the respective authors are very divergent. There is, however, one point of which there can be no doubt, *i. e.*, the Pliocene exchange of North and South American types. It must be decided by North American zoologists whether this interchange has commenced at the close of the Miocene or only in the Pliocene. We may therefore consider as Pliocene the Argentine Araucanian formation, where the northern Artiodactyla and other North American immigrants first appear; the Entrerian formation, containing the neotropical forms must then be Miocene. This formation was considered by Ameghino Eocene (1889), or Oligocene (1898), and by the writer (1898), Miocene. In favor of his opinion Ameghino quotes the result of the study of G. Alessandri on the fossil selachian teeth of Entrerios which he believes to be Eocene. Mr. A. Smith-Woodward, to whom I have sent the material of our museum, writes me: "I conclude that the formation cannot be earlier than Miocene and is probably Pliocene." I have called attention to the fact that in the Entrerios deposits occurs *Monophora darwini*, a Scutellid with perforated disk which is common in the corresponding formation of the north Patagonian coast. No Scutellidæ with perforations of the disk are known earlier than the Miocene. On the other hand, the Mollusca of this formation are almost all extinct species and therefore I cannot believe it Pliocene.

Zittel in his 'Manual' has well explained the relations between the two American mammal faunas. I am, however, disposed to believe, contrary to him and to Ameghino, that the genus *Didelphys* in South America appears as a member of the North American immigration. If derived from the Patagonian Microbiotheriidæ, as suggested by Ameghino, this genus may have issued in the earlier Eocene time from Patagonia and Archinotis and, after having reached Europe in the Eocene and North America in the Miocene, turned to South America in the Pliocene. If Ameghino is right, the Proboscidia are derived from the Eocene Patagonian Pyrotheriidæ and, after having appeared in Europe and North America, returned to Argentina during the Pliocene in the form of the Mastodon.

If this migration is a relatively well established fact, it is quite doubtful in what manner Patagonia received its rich mammalian fauna in the Laramie period. Florentino Ameghino pointed out that this must have occurred by means of a land-bridge which united both Americas at the beginning of the Tertiary period. On this matter there has been a discussion between Ameghino and the writer in the *Revista Argentina de Historia Natural*, Vol. I., Buenos Ayres, 1891, p. 122 ff. and p. 281 ff., in which I have combated this hypothesis. The fresh-water faunas of the two Americas, as I have shown, are so completely different that only a prolonged and absolute separation can explain the fact; the geological history of both North and South America demonstrate an enormous development of the Cretaceous Ocean, separating the two Americas, and in the Tertiary period the North American territory increased but slowly. This presumed primitive connection of the two Americas is not at all supported by facts, but only based on the predominance of wrong ideas of the history of the Australasian Territory. The Eocene mammals of Patagonia and North America certainly do not justify this hypothesis. The Eocene faunas of Reims and

Puerco, although these localities are much more distant from each other than North and South America, correspond closely, but the characters of the earliest Tertiary Patagonian and North American mammalian faunas are quite divergent. We find nothing of the Toxodontia, Typotheriidæ and true Edentata in North America, and nothing of the Artiodactyla, Perissodactyla, Amblypoda, etc., in Patagonia. The orders and families which *are* represented in both Patagonia and North America may be such as were distributed over the whole area occupied by placental mammals in the Laramie period.

The third line of migration according to Ameghino and Osborn was determined by the land masses which connected Brazil and Africa. In my papers, and especially in the discussion with Ameghino, I have insisted upon the value of this Eocene land bridge, but I do not believe that it has served for the distribution of mammals, as I believe that Archamazonia was in the greater part of the Tertiary separated by the ocean from Archiplata. In this case Brazil has received mammals only in the Pliocene time, when the communication with Africa had long ago been interrupted. I have examined the deductions of Ameghino and Osborn with the purpose of verifying the facts proving their opinions, but these seem to be very insufficient. Osborn refers to the Pangolins and Aard Varks of the Æthiopian region as introduced from South America 'via Antarctica.' It must, however, be noted that these Edentata of the old world occur also in Asia and that they belong to the Nomarthra, while all the Patagonian representatives are Xenarthra. Both may be derived from a common Australasian ancestor, but if the South African Edentata had been derived from the Patagonian Eocene fauna, they should be Xenarthra. The genus *Orycteropus* occurs also in the Miocene of Samos, and may have immigrated both to Samos and to Africa from its Indo-australian home. It may be observed here that I have shown that the claw of the Dasypodidæ develops in the form of a hoof, and it is wrong to classify the Xenarthra with the Unguiculata, as they are Ungulata. The Proboscidea and Hyracoidea are not Patagonian mammals at all, although in the Patagonian Laramie or Pyrotherium fauna the Pyrotheriidæ and Archæohyracidæ offer relations to the two above-mentioned living families. The case is the same with the sole Patagonian Insectivore, the genus *Necrolestes*, somewhat comparable with the Chrysochloridæ of South Africa. Evidently the few representatives in the Patagonian Eocene of the Insectivora, Prosimiæ and Hyracoidea are the isolated members of groups which were well represented in other regions then in connection with Patagonia. Thus the Chrysochloris argument for the Patagonian-South-African migration is not better than the hypothesis of a land-bridge uniting the Antilles with Madagascar, the sole localities where representatives are found to-day of the genus *Centetes*, which occurs also as Wallace affirms in the European Tertiary.

The intimate relations between the fresh water faunas of Africa and Brazil, and the colossal difference which exists between the fresh water faunas of Archamazonia and Archiplata, prove that both territories during the greater part of the Tertiary were separated quite as completely as the two Americas. In this case the mammalian fauna of Patagonia may have reached Ecuador or Colombia by means of the upheaval of the Andes, but not Brazil, and both Brazil and the Æthiopian region may have been without mammals and especially placental mammals, during the Eocene. When toward the close of the Eocene this land-bridge was submerged, there already existed many types that have been conserved

until our time, and thus we find existing on the Central American and Brazilian coasts the same species of mangrove plants, and with them numerous identical forms of Crustacea, Mollusca, etc.; the distribution of Manatus must also be cited here.

We now turn to the relations of South America with Australia and New Zealand. As the views put forth on this point by Hutton and the writer seem to be now generally accepted, there is no reason for discussing the question here. It may be observed, however, that not only does the fresh-water fauna give evidence of an antarctic land bridge between Australia, New Zealand and Patagonia, but also numerous other zoological as well as botanical and paleontological facts. Osborn says only that this migration established the links with Australia, 'bringing in Marsupials, both polyprotodont and diprotodont.' Ameghino (Censo, p. 250) says that on this vast antarctic land was distributed the cretaceous mammalian fauna which he has described. No other conclusion is logically possible, and we cannot doubt that the Eocene fauna of the Australian region, though not at all known to-day, must have been very analogous to and in part identical with the Patagonian.

The different adaptive radiations of orders and families have given a very different aspect to the existing faunas of Australia and Patagonia, in Australia only Monotremates and Marsupials having survived, in Patagonia principally histricomorph Rodents and Edentata. The existing fauna of Australia, New Guinea and other allied islands has received by Miocene immigration some placental mammalia, as *Canis* and *Uromys* in Australia, *Sus* and *Uromys* in New Guinea, and other genera in the Moluccas. This proves that Australia and New Guinea, at least during the Miocene, continued to be connected with Asia as in the foregoing periods. There existed therefore in the earlier Tertiary a continuous land mass from Antarctica and Patagonia, via Australia and Asia, to Europe and North America. This enormous territory, my Eurygæa, was the birthplace of the placental mammals. The Stenogæa (or Archhelenis) extending from tropical South America to Africa, Madagascar and Bengal was in the Eocene without mammals.

It is certain that we have to-day no knowledge at all of the Eocene mammals of Australia, Brazil and Africa, but from the facts given it seems to be highly probable that future discoveries may confirm what we expect.

Paleophytical studies have given evidence of a great resemblance between the Cretaceous floras of North America and Eurasia. According to Fr. Kurtz, the same flora appears also at St. Cruz, Patagonia em Cerro Guido (*Revista Museu La Plata*, Vol. X., 1899, p. 43 ff.). According to the facts given above, this flora cannot have reached Patagonia from North America, as the two Americas were then separated and no South American continent existed. It is also impossible to admit that a land bridge formed by the Andes served for the migration, because these did not then exist, as the Cretaceous marine beds of the Andes prove. There must then have been a connection between the Antarctic Cretaceous continent, the Archinotis of the writer, and Asia. It may be observed that the genus *Quercus* was represented in the Cretaceous beds of both Patagonia and Australia, where to-day it has no representative. What has occurred in the case of *Quercus* and other genera in both Australia and Patagonia and what is observed in Patagonia with reference to mammals may have happened also in Australia to the earlier placental mammals. Further, it must be remembered that Australia, and South America also, developed by coalescence of different parts, each of which had its own history.

I may note here one more fact referring to the fresh water fauna: the dispersion of the cyprinoid fishes. These Holarctic fishes did not reach Australia, already isolated by the sea, but invaded Africa and Madagascar. Lemuria must therefore have persisted in connection with Asia, when the Australian region was already isolated. Thus Africa offers the same mixture of ancient indigenous elements and Neogene immigrants as Argentina and Southern Brazil, on account of the intrusion of archamazonic immigrants. Had this invasion occurred in the Eocene period, the Cyprinidæ would have reached Brazil; supposing it to be Pliocene, these fishes would not have reached Madagascar. Probably Africa received its placental mammals at the same time that the invasion of Cyprinidæ into Africa took place, one of the most remarkable events in zoogeography.

We have no knowledge at all of the Cretaceous and Eocene mammals of Brazil, Guyana, Africa and Australia; it is impossible to give a complete history of the mammals with incomplete materials. But combination of the known facts makes it probable that during the Cretaceous and Eocene period Archhelenis, or Stenogæa, was without placental mammals and that their origin was in Eurygæa. In regard to the flora the same holds good for many families of wide distribution, as for example the Cupuliferæ.

With reference to the terms used by Blandford, Lydekker and the writer, it must be said that the intention of the first two was to give names to *existing* zoogeographical regions, while the terms introduced by me refer to *supposed*, *ancient* zoogeographical and geographical regions. The two great Cretaceous continents Eurygæa and Stenogæa may have existed also during a part of the Eocene period and then dismembered. From Stenogæa, or Archhelenis, were separated first Bengal and then Madagascar, while Archamazonia after the loss of the connection with Africa consisted of Archiguyana and Archibrazil. Eurygæa split into (1) Archiboreas corresponding to the actual holarctic region and (2) Archinotis from which, in the Eocene, Archiplata was separated.

The comparison of the distribution of the mammals with the fresh water fauna makes especially evident the differences in the geographical conditions which must have determined their distribution. While the distribution of the existing types of mammals is a result of changes in geography during Tertiary time, the most fundamental facts in the distribution of the fresh-water fauna dates from the Mesozoic epoch. The fresh-water fauna of Chili preserved such a remnant of the Cretaceous fauna almost intact, and even the connection between the two Americas has not at all modified the South American fresh-water fauna. On the other hand, representatives of the Archamazonian fauna, in correlation with the geographical modifications of Central America and the Antilles have invaded the southern parts of the nearctic region. Thus in the Rio Usumacinta of Mexicao beside Cyprinidæ and Chromidæ we find also Characinidæ and Lepidosteus, also species of *Glabaris* intermediate between the northern Unios and Anodontas. There is a further difference in the distribution of mammals and fresh-water mussels. The former migrate on land bridges in both directions, the fresh-water fauna generally in only one, due to the opportunity given by the currents. Thus although there was an invasion of Cyprinid fishes into Africa there was no corresponding emigration of Æthiopian types. A similar fact is the sudden appearance of the Æthiopian faunal elements in the valley of the Nile, which occurred only at the close of the Pleistocene, as proved by paleontological facts. While the Pliocene connection of the two Americas was sufficient to mod-

ify the distribution of the mammals in such a way that without paleontological researches it would be impossible to recognize the origin of the different faunal elements, the fresh-water faunas have resisted almost unchanged all modifications in the configuration of the continent.

The fresh-water fauna is not only older but also much more conservative than the distribution of the mammals. One of the most striking examples of this is given by the history of Africa. While the characteristic mammals are Neogene immigrants and Lydekker proceeds quite correctly in making Africa an annex only of the Holarctic region, thus establishing his Arctogæa, with relation to the fresh-water fauna, Africa is a part of South America, somewhat modified by the Neogene invasion of Cyprinid fishes. If as regards mammals Africa belongs to Arctogæa, with relation to the fresh-water fauna it belongs to the Archhelenic region.

This example demonstrates *the absurdity of the present system of construction of zoogeographical regions and maps. We can construct maps of the different classes and orders but not at all of the animal kingdom, because the geological history of the different groups is quite different.* When Osborn says that it is one problem 'to connect living distribution with distribution of past time,' he says only what had been the leading idea of Wallace and of Engler in their eminent works on zoo- and phytogeography, but when he continues 'and to propose a system which will be in harmony with both sets of facts,' he proposes a problem just as contradictory as would be the construction of descriptions and figures referring at the same time to egg, larva, nympha and imago of an insect. The works on 'zoogeography' are almost exclusively discussions of the distribution of mammals and birds, and the few words spent on other classes are only ornamental supplements. A wrong method cannot give valid results. For the exploration of the zoogeographical relations and regions of the beginning of the Tertiary and of the preceding Mesozoic epoch it is necessary to study and to discuss the more ancient classes and, as I have insisted for ten years, principally the fresh-water fauna.

H. von Ihering.

São Paulo, July 20, 1900.

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*A HISTORY OF THE DEVELOPMENT OF THE QUANTITATIVE STUDY OF VARIATION.**

The quantitative study of variation has for its object the investigation of evolution by exact, quantitative methods. The study demands a mathematical method as well as a biological subject matter; consequently the development of the science has proceeded along two main lines—the one biological and the other mathematical. Accordingly, the history of the development of the quantitative method involves a consideration of both the study of variation and the elaboration of the necessary method.

The fact of variation has been recognized since man began to think and to appreciate that in stature, color and mental capacity his fellow-men are diverse. The way for quantitative studies in biology was paved by the mathematical studies on the variation of measurements which engineers and astronomers found it necessary to make for their own purposes. These mathematical studies led to the discovery and elaboration of the law of error by Gauss and others—and this law is the corner-stone of the quantitative biological studies.

The application of the law of error to organic variation was, apparently, first made by an anthropological statistician, of the early part of the century, named Quetelet. In his book, entitled 'Lettres à Son Altesse Royale le Duc de Saxe-Coburg et

* Being part of the report of the Committee of the American Association for the Advancement of Science on the Quantitative Study of Variation.

Gotha sur la théorie des probabilités appliqués aux sciences morales et politiques,' published in Brussels, 1846, and translated into English by O. G. Downes, 1849, Quetelet applied the mean and probable error to the designation of the peculiarities of different races of men; and he even compared an observed distribution of frequencies of human statures with a theoretical one calculated from the mean and the probable error by the use of the formula,

$$y = \frac{2}{\sqrt{\pi}} \int_0^t e^{-t^2} dt.$$

The possibilities of an extension of this method of quantitative analysis to biological variation in general were, however, during twenty years unrecognized, for the time was not yet ripe.

Meanwhile, on the biological side the clouds of a revolution were rising. During the fifties the variation of animals in nature was much discussed. In 1856 Wollaston wrote a book 'On the Variation of Species,' and at a meeting of the British Association, in the same year, Jenyns called for exact data on the variation of organisms. Then came the 'Origin of Species,' 1858, 1859, which used the facts of variation to enforce the conclusion of the mutability of species. At that time the study of the variation of species received a great impetus, but for forty years the observations have been for the most part qualitative or only roughly quantitative. Among the most important synoptic works on variation have been Darwin's 'Variation of Animals and Plants under Domestication,' 1868, and Bateson's 'Materials for the Study of Variation,' 1894.

To the rule that until a decade ago studies in variation were qualitative, the anthropological studies have formed a striking exception. Anthropologists have been forced to measure by the necessity of making fine discriminations, and have sought by statistical methods to get the most out of the resulting data. The first to advance beyond Quetelet was Francis Galton, cousin of Darwin, and already well known on account of his studies on heredity. In 1870, in his book on 'Hereditary Genius,' he used Quetelet's method of applying the law of error to organisms. He used it especially to get a quantitative definition of his grades of ability, A to G. In 1879, Galton made a further and important step. He pointed out that "an assumption which lies at the basis of the well-known law of 'Frequency of Error' (commonly expressed by the formula, $y = k \cdot e^{-h^2x^2}$) is incorrect in many groups of vital and social phenomena." The assumption which Galton combats is "that errors in excess or in deficiency of the truth are equally probable or conversely, that if two fallible measurements have been made of the same object their mathematical mean is more likely to be the true measurement than any other quantity that can be named." Galton goes on to show that this assumption cannot be justified in vital phenomena; for example, in guesses at a color containing 8 parts of white, we are equally apt to err by selecting one with 16 parts and one with 4 parts, yet the error in one case is twice the error in the second case. Conversely, in two guesses at a mid tint, the most reasonable conclusion is not the arithmetic mean of the two, but the geometric mean. If the guesses are 4 and 16, the most probable value is not $\frac{4+16}{2} = 10$ but $\sqrt{4 \times 16} = 8$; for $4 : 8 :: 8 : 16$. Galton then extends this case to biological measures in general and calls for a law of error based on the geometric mean. At his suggestion Mr. Donald McAllister worked out a more general form of the probability curve, applicable to a distribution of frequencies based on geometric error, and obtained the result,

$$y = \frac{1}{x\sqrt{\pi}} h^{-h^2 \log.^2 x}.$$

At about this time also, the anthropologist Stieda called attention in Germany to the application of the probability methods to anthropological statistics. His paper published in the *Archiv für Anthropologie*, Band XIV., entitled 'Ueber die Anwendung der Wahrscheinlichkeitsrechnung in der anthropologischen Statistik,' 1883, has had great influence in extending the use of the method. In this work the measure of variability is the probable error, here called the 'Oscillations Index.'

During the eighties, Galton, in a remarkable series of papers, developed the quantitative theory of individual variation. In 1885 he introduced a graphic method of determining the probable error, using his 'ogive' or normal curve of distribution of error. In connection with his studies on pedigree peas he developed the theory of the mid-parent, the law of regression of the progeny of extraordinary parents toward mediocrity, and the law of ancestral inheritance, according to which the mid-parent contributes one-half, the mid-grand-parent one-fourth, the mid-great-grand-parent one-eighth, and so on, of the whole heritage. In 1888, Galton made another important step. He obtained a method—somewhat rough, to be sure, because chiefly graphic—for measuring *correlation* between two organs. The measures of one organ, called subject, were taken, the mean found and the measures grouped into classes expressed in terms of the deviation from the mean divided by the probable error of the subject. The average of the corresponding measures of the other organ, called relative, was found, and the deviation of the average from the mean size of the organ was expressed in units of the probable error of the relative. The average (found graphically) of the ratios of the deviation of the relative divided by the deviation of the corresponding subject class gives the correlation-index sought.

The culmination of this epoch-making work of Galton was his 'Natural Inheritance,' 1889, which applied the quantitative methods he had elaborated to the data of human inheritance which he had himself gathered. The book is important, not so much for its new material, for much of the matter had appeared elsewhere, but because it called attention to the possibilities of the quantitative method applied to biology generally. But probably of even greater effect were Galton's personal suggestions to biologists such as Weldon and to mathematicians such as Pearson. At any rate, the beginning of the new decade saw the beginning of a wider interest in the quantitative study of variation; and the source of this wider interest can be traced directly to one man—*Francis Galton*.

While the impetus to the modern quantitative variation studies came from Galton, quantitative studies, in zoology at least, were not unknown before 1890. In our own country, Baird, Coues and J. A. Allen had measured numerous individuals of each of many species of mammals and birds and had published tables of measurements. Allen, in particular, had grasped the importance of the quantitative study of variation, had compared the average dimensions of mammals and birds from different parts of the country and had established* a law of relation between the size of individuals and their distribution which has proved very fertile.

As long ago as 1829, H. Milne-Edwards† gave a table of variations in size of various parts of the body of fourteen individuals of

* J. A. Allen, 'On the Mammals and Winter Birds of East Florida,' etc., Bull. Museum Comparative Zoology at Harvard College, 1871, and 'Geographical Variation among North American Mammals,' Bull. U. S. Geol. and Geog. Survey, Vol. II., 1876.

† *Annales des sciences naturelles* (1), 16, p. 87.

Lacerta muralis. Students of molluscs have also been led in a few instances to quantitative studies. One of the most important of these was that of Bateson, who showed by a series of measurements the gradual change in form of the cardiums on the terraces of an inland sea which is gradually becoming denser.

From 1890 on, the published works in the field we are considering became more numerous and appeared simultaneously in several countries and stimulated from various sources. It was early in this decade, too, that the remarkable series, by Pearson and his pupils, of mathematical contributions to the theory of evolution, began to appear. Since these papers profoundly affected biological work, it will be well to consider them first. We may then consider in turn the English biological school—especially the work of Weldon and his pupils—the continental biological work, and finally that of America.

In 1894 Professor Karl Pearson published the first of his valuable series of papers on the mathematics of evolution, entitled 'On the Dissection of Frequency Curves.' While the primary result of these investigations has as yet proved of no great service, the methods elaborated have formed the basis of all Pearson's later analysis. These methods consisted of the analytical investigation of the frequency curve by reduction to the first to fifth movements about an assumed vertical axis. The root of the mean square error was employed as the best measure of variability and was called the standard deviation.

Pearson's second paper: 'Skew Variation in Homogeneous Material,' 1895, is the basis of the newer quantitative methods. Starting with the recognition of the fact that the vast majority of biological frequency curves are not symmetrical but 'skew,' Pearson undertakes an analysis of distribution curves in general, gets a general formula and concludes that there are five types of curves altogether. These are the normal curve—which is symmetrical and has an infinite range; the symmetrical curve with limited range; the skew curve with range unlimited in both directions, with range limited in both directions, and with range unlimited in one direction and limited in the other. The analysis of skew frequency curves was not entirely new, for it had previously been made by an American, E. L. De Forest, of Connecticut. But Pearson's work, having especially a biological aim, has become generally adopted by biologists. In 1897 there was published, posthumously, an analysis of frequency curves by Fechner; but Fechner's treatment is much clumsier than Pearson's. Within recent years a fresh analysis of skew curves has been made by the English mathematician, Edgeworth in the Philosophical Magazine. Sheppard, too, has contributed methods of analysis of frequency curves. All these will doubtless eventually be of service to biologists.

Pearson's third paper, 1896, was devoted to the theory of correlation, which he placed on an analytical basis. His method of getting the index of correlation was a long one, which Duncker has greatly simplified in his paper published a year ago.

Pearson's fourth paper, published jointly with L. N. G. Filon in 1898, dealt with the probable errors of frequency constants and is of great importance for measuring precisely the degree of unreliability of any result. Pearson's later papers, many of which are published under the uniform title 'Data for the Problem of Evolution in Man,' have elaborated and extended the results of his earlier works.

The results of the last six years, then, have placed the analysis of biological frequency curves at once upon a satisfactory scientific basis. But the limit of improvement in the method of analysis is by no means reached.

Passing now to the biological results, we consider first the work done in England, for it was there, in the home of Galton and Pearson that the new methods found their first application. Of the papers of the new era the first is that of Weldon, 1890, entitled 'The Variations occurring in Certain Decapod Crustaceæ. I. Crangon Vulgaris.' Proceedings of the Royal Society of London, Vol. XLVII, pp. 445–453. This study was undertaken to test Galton's prediction * that selection would not alter the distribution of frequencies in any race. Weldon measured four dimensions in several hundred individuals, calculated the means and probable errors, compared the observed and theoretical frequencies and concluded that Galton's prediction is fully justified. He showed, in addition, that the variation in size of the organs measured occurs with a frequency indicated by the law of error and that the 'probable error' of the same organ is different in different races of the same species.

Next Weldon obtained measurements of the variation of the shrimp *Palæmonetes varians* in Plymouth, which have lately been made the basis of comparison with our American shrimps by Duncker and by Johnson and Hall. These comparisons have established that the otherwise very similar English and American shrimps have modal numbers of rostral spines which are respectively 4 and 8. In 1892 Weldon studied correlative variation in the prawn *Crangon vulgaris* and drew the conclusion that a wide knowledge of the specific constants would give an altogether new kind of knowledge of the physiologic connection between the various organs of animals.

In 1893 Weldon published a fourth paper, on correlated variations in *Carcinus mœnas*, in which he dealt with ratios of various dimensions of the body to the carapace length. It was in these studies that Weldon came across a distribution of frequencies which did not conform with the theoretical distribution, and which Pearson subsequently resolved into two symmetrical curves. Weldon found the coefficient correlations between similar organs in different races to be closely alike.

While Weldon was making these studies, Bateson and Brindley published (1892) their quantitative studies on the length of the forceps of male earwigs, on the length of the cephalic horns of a rhinoceros beetle and on the length of the mandibles and the elytra of a stag beetle. In the first two cases there was a marked discontinuity in the variations. Thus the forceps had modes at 3.5 millimeters and 7 millimeters, and the horns had modes at 4 and 9.5 millimeters. In 1895 Bateson gave statistics of the marvelous variation in color of a chrysomelid beetle, but the data hardly admitted of exact quantitative analysis.

In 1895, Weldon presented to the Royal Society his first report of the committee for conducting statistical inquiries into the measurable characteristics of plants and animals. In this report he gives the results of studies on selective destruction of the rock crab. The climax of the studies of Weldon and his pupil, Thompson, on the rock crab is his presidential address before the British Association (1898) in which he showed that the proportional size of the frontal margin of the crab's carapace had at Plymouth, during the preceding five years, diminished five per cent. Consequently he has been able by means of the quantitative method to measure a real evolutionary change. Moreover, he has been able to put his finger on the cause of this change, for he showed that the silting up of the harbor of Plymouth, and the greater quantity of mud in the harbor, tends to kill off the crabs with broad gill-openings and to let survive only those with narrow gill-openings and a narrow gill (or frontal)

* Natural Inheritance, pp. 119–124.

margin. The expectation, then, that quantitative studies would quickly demonstrate that evolution is going on rapidly in certain instances to-day has been realized.

Another of Weldon's pupils, Warren, has provided statistical data on variation in the crab *Portunus*, and on the variation of ancient, barbarous races as compared with modern civilized ones. More recently he has measured quantitatively the effects on the little crustacean *Daphnia* of various external conditions. Vernon, likewise, has given quantitative data on the effects of external conditions on the development of echinoid larvæ and on echinoid hybrids. Finally, the recent confirmation by Galton of his law of Ancestral Inheritance demands brief mention.

The continental school of variation students includes chiefly botanists. Very early (1887) F. Ludwig, of Greiz, began to make quantitative studies on the variation in the number of ray flowers of the white daisy. These studies he continued and extended to other species, and has published the results in a series of papers appearing in the *Botanisches Centralblatt* from 1895 to the present time. He finds that the variation curves of plants are more frequently multimodal than are those of animals. Ludwig has published two comprehensive papers, in 1898 and 1900 respectively, which have served to extend a knowledge of the new method. At Amsterdam, de Vries has applied statistics to his experimental, chiefly *selective*, plant breeding. He has produced new races of certain very variable species within two to four years. Verschaffelt, a student of de Vries, did good service in calling attention to the importance of the coefficient of variation (or the index of variation divided by the average) for comparative purposes. Verschaffelt also suggested an ingenious measure of skewness, which is very simple but has been largely replaced by Pearson's index. Important work has also been done by L. MacLeod, of Ghent, Belgium, and his pupils, in papers published in Dutch in the *Botanish Jahrboek*.

Among the continental zoologists Heincke was the first in the field. He has applied statistics especially to questions relating to the existence of local races of fishes, and especially the herring. George Duncker, a student of fishes, has been occupied with biological statistics since the early part of the decade. He has written an excellent general treatise on the subject, (1899) in which the more important methods of Pearson are simplified and thus made more generally available. In Italy, Camerano has made a beginning with the quantitative methods.

In America quantitative studies of human variation have been made by anthropologists incited by the work of Galton. Prominent among these are Bowditch, Porter and Boaz. Minot also has made use of Galton's methods. Within late years Bumpus (1897–1899) has applied Galton's methods to variation of *Necturus*, and to the problem of the relation of variation to environment and to selection. Eigenmann and his student, Moenkhaus, have given data on the differences in the *mode* of certain fish characters in successive years and in different environments. The writer and his pupils, Blankinship, Brewster, Bullard and Field, have contributed certain quantitative data upon some of Darwin's laws of variation and upon correlation. The writer has also published a small book on the newer methods which, containing the principal formulæ and tables for calculating curve constants, it is hoped may be found useful by students of the new methods.

To sum up, the quantitative study of biology, the modern impulse to which we owe to Galton, has been furnished with good methods by Pearson. Already the application of these methods has borne fruit in our knowledge of the types of bio-

logical frequency curves, and their change with changing place and environment. The idea of correlation has received a precise definition. The results of experimentation have been quantitatively expressed. The rôle of natural selection, the method of evolution and the laws of inheritance are being discovered. Already we are able to predict greater results from the quantitative method in biology, especially where combined with experimentation, than any which have yet appeared.

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PLANT GEOGRAPHY OF NORTH AMERICA.

COMPOSITION OF THE ROCKY MOUNTAIN FLORA.

IN Southern Wyoming the Great Plains extend across the continental divide, making a break in the Rocky Mountain chain, and dividing it into two groups, the Southern and the Northern Rockies. The former are for the greater part in the State of Colorado, but extend into northern New Mexico as well as southern Wyoming. The Wasatch and Uintah Mountains, although separated from the main claim by the Green River Basin, may also be noted here.*

The Northern Rockies begin in northern Wyoming, but have their best development in western Montana, northern Idaho, western Alberta and eastern British Columbia. The chain also extends into Alaska and Yukon Territory, but the flora of this region is partly very little known and so merged into the Pacific Coast flora that it deserves a separate treatment. Some isolated mountains, as for instance the Black Hills of South Dakota and the Little Rockies and Bear Paw Mountains of Montana, may also be mentioned here.

*The mountains of southern New Mexico and Arizona may also be accounted to the Rocky Mountain system, but their flora is so different and contains so many Mexican and Sonoran elements that it is better to exclude them from this discussion.

The flora of the two groups is essentially the same, but some differences are found. These are most evident in the coniferous vegetation. So are for instance *Pinus edulis*, *Pinus aristata*, *Picea Parryana* and *Abies concolor* confined to the Southern Rockies, while *Pinus Murrayana*, *Picea Columbiana* and *Abies grandis* take their place in the Northern. *Psudotsuga mucronata*, *Picea Engelmannii* and *Pinus flexilis* are equally common in both regions.

The flora of the mountain regions is made up of the following elements:

1. The ENDEMIC FLORA OF THE ROCKIES, which constitutes the largest element. In Montana it is represented by 33 per cent. of all the species and in the Southern Rockies the proportion is much larger.

2. The TRANSCONTINENTAL FLORA, made up mostly of hydrophilous plants.

3. The BOREAL FLORA OF NORTH AMERICA, which in British America is more or less transcontinental, but in the United States is found principally in the mountain regions. It is made up mostly of hylophilous plants, but also represented by some hydrophilous ones, as for instance members of *Cyperaceæ*, *Salicaceæ* and *Ericaceæ*.

4. The ARCTIC FLORA, found only on the tops of the highest peaks at an altitude of over 3,000 m. in Montana and over 4,000 m. in southern Colorado.

5. The CASCADE MOUNTAIN FLORA, which merges with that of the Rockies in British Columbia and partly extends south into Montana and Idaho.

But in discussing the flora of the Rockies, one must not only take in consideration that of the mountain regions, but also that of the intermingling plains, valleys and foothills. If this is done, several new elements must also be considered.

6. The FLORA OF THE GREAT PLAINS. The Great Plains consist of high dry tablelands and make up a large portion of Saskatchewan, Assiniboia, eastern Montana

and Colorado, eastern and central Wyoming, and western Dakotas, Nebraska and Kansas. They have a flora of their own, mostly consisting of xerophilous plants, but in the valleys along the water courses are brought in besides the transcontinental flora mentioned above, also a few of another element, viz:

7. The PRAIRIE FLORA OF THE MISSISSIPPI VALLEY. The species of the typical Alleghanian flora found in the Rockies are so few that they may practically be disregarded. In all cases they are also represented in the Prairie flora.

8. The FLORA OF THE STAKED PLAINS, which extends into southeastern Colorado and northeastern New Mexico. The Staked Plains, with their best development in northwestern Texas, are but a southern extension of the Great Plains, but contain numerous plants not found on the latter, so that its flora may well be treated separately.

9. The SONORAN FLORA, the general flora of the table-lands of northern Mexico, Arizona and southern and western New Mexico.

10. The GREAT BASIN FLORA of Nevada, Utah, southern Idaho and southeastern Oregon. This can almost be regarded as a desert flora. It is also met with outside of the Great Basin, especially in many places in the Green River valley of Wyoming, Utah and Colorado.

11. The COLUMBIA VALLEY FLORA. This flora extends along the headwaters and tributaries of Columbia River into the Rockies of Idaho, Montana and British Columbia.

A flora made up of so many elements must naturally be very varied and exceedingly interesting. A comparison may well be made with that of the Alleghanies on one hand and that of the Cascade Mountains and Sierra Nevada on the other. If this is done we find that the flora of the Rockies resemble more the latter than the former.

The bulk of the forest of the Rockies is made up of Conifers. Most of these are common to the region and mountains of the Pacific Coast, but none of the trees are found in the Alleghanies or around the Great Lakes. The White Spruce, *Picea Canadensis*, has been reported from northern Montana and Alberta, but I think erroneously so. Probably *P. Columbiana*, which resembles it in habit and the glabrous branches, has been mistaken for it. *P. Columbiana* is otherwise much more closely related to *P. Engelmannii*. Two prostrate shrubby species of *Juniperus*, *J. Sibirica* Burgsd. and *J. postrata* Pers. range across the continent. Both are subarctic and subalpine. Besides these none of the Rocky Mountain conifers are found in the East, although they are often represented there by closely related species.*

* List of the Rocky Mountain Conifers and their representatives in the East and on the Pacific Coast

Rocky Mountains.	East.	Pacific Coast.
Pinus flexilis *Pinus albicaulis*	.....	*Pinus flexilis* *Pinus albicaulis*
Pinus monticola	*Pinus Strobus*	*Pinus monticola* *Pinus Lambertina*
Pinus edulis	....	*Pinus monophylla*
Pinus aristata	.....	*Pinus aristata* *Pinus Balfouriana*
Pinus ponderosa *Pinus scopulorum*	*Pinus resinosa*	*Pinus ponderosa*
Pinus Murrayana	*Pinus Virginiana* *Pinus divaricata* *Pinus echinata*	*Pinus Murrayana* *Pinus contorta*

Among the deciduous trees and shrubs, the number of species common to the Rockies and the East is much larger. Many of these common species are boreal, but some are truly transcontinental or nearly so.

Of the SALICACEÆ about three-fifths of the Rocky Mountain species are endemic or western. The rest are nearly all boreal. The only ones that cannot come under these categories, as far as I can remember, are *Salix Bebbiana*, *S. candida* and *S. cordata*. The eastern *Populus deltoides* is represented in the Rockies by a western variety.

Of BETULACEÆ, *Betula papyrifera*, *B. glandulosa*, *Alnus Alnobetula* and perhaps *A. incana* are found both in the Rockies and in the East. The other four Rocky Mountain species are western.

Of FAGACEÆ, *Corylus rostrata* is common to the Rockies and the East. Besides by this species, the family is represented in the region by a few endemic low species of *Quercus* of the White Oak group.

ULMACEÆ is represented by three or four species of *Celtis*, of which *C. occidentalis* is found in the East. *Ulmus Americana* is found here and there in the valleys of the Great Plains, but scarcely reaches the Rockies.

All woody species of HYDRANGIACEÆ, GROSULARIACEÆ, ROSACEÆ, POMACEÆ, DRUPACEÆ, PAPILIONACEÆ, RUTACEÆ, RHAMNACEÆ, ACERACEÆ, CELASTRACEÆ and ANACHARDIACEÆ are endemic or western, except four species of *Ribes*, four of *Rosa*, *Rubus strigosus*, *Dasifora fruticosa*, *Sorbus sambucifolia*, *Prunus Americana*, *P. Pennsylvanica*, *Amorpha fruticosa*, *Rhamnus alnifolia*, *Acer Negundo* and *Rhus glabra*, which are also found in the East.

The two species of VITACEÆ found in the Rockies, viz., *Vitis vulpina* and *Partenocissus quinquefolia* extend to the Atlantic coast, and so also the three species of ELÆGANACEÆ.

Taken as a whole, scarcely 20 per cent. of the woody plants of the Rockies are found in the Alleghanies or around the Great Lakes. Nearly all those common to both regions are transcontinental or boreal species. If on the contrary, the woody flora of the Rocky Mountains were compared with that of the mountains of the Pacific Coast, one would find that at least 50 per cent. of the former would be represented in the northern Cascade Mountains, which in British Columbia are more or less contiguous to the Rockies.

It has been impossible for me to make a detailed comparison of the general flora of the Rockies with that of the East on one hand and with that of the Pacific States on the other. In my catalogue of the flora of Montana and the Yellowstone Park, I made such a comparison, and I think that the conclusion reached there with some modification may serve for the whole Rocky Mountain region. The catalogue contains 1,976 species and varieties. Of these 487 are found both east and west of the mountains and 268 only east thereof, or in other

Larix occidentalis *Larix Lyallii*	*Larix laricina*	*Larix occidentalis* *Larix Lyallii*
Picea Parryana *Picea Engelmannii* *Picea Columbiana*	*Picea Canadensis* *Picea rubra* *Picea Mariana*	*Picea Sitchensis* *Picea Engelmannii* *Picea Columbiana*
Pseudotsuga mucronata	(*Tsuga Canadensis*)	*Pseudotsuga mucronata*
Abies grandis *Abies amabilis* *Abies concolor* *Abies lasiocarpa*	*Abies balsamea*	*Abies grandis* *Abies amabilis* *Abies concolor* *Abies lasiocarpa, etc.*
Thuja plicata	*Thuja occidentalis*	*Thuja plicata*
Juniperus scopulorum *Juniperus Knighti*	*Juniperus Virginiana*	*Juniperus California*
Juniperus occidentalis *Juniperus monosperma*	.....	*Juniperus occidentalis* *Juniperus monosperma, etc.*
Juniperus prostrata	*Juniperus prostrata*	*Juniperus prostrata*
Juniperus Sibirica	*Juniperus Sibirica*	*Juniperus Sibirica*
Taxus brevifolia	*Taxus Canadensis*	*Taxus brevifolia*

words 755 of the Montana and Yellowstone Park species are extending eastward. This includes transcontinental and boreal plants, as well as plain and prairie species. Of these not more than half or not fully 20 per cent. of the whole number reach as far east as the Alleghanies or the Great Lakes. If the flora of Colorado should be compared in a similar way with that of the east, one would find that a much smaller number of species was common to the two. It is therefore safe to say that not 20 per cent. of the plants of the Rockies are found in the Alleghanian region and that these consist almost exclusively of transcontinental and boreal plants.

In comparing Montana with the Pacific Coast, I found that 487 (mostly transcontinental and boreal plants), plus 520 (mostly Columbian and Cascade Mountain plants) or 1,007 species or nearly 51 per cent. of the plants of that State are also found west thereof. These figures can not be taken as a fair average, for in Colorado we find fewer plants that are common to that State and the Pacific Coast. I should judge that even 20 per cent. would there be a high number. I think, however, that it is safe to say that between 30 and 40 per cent. of the plants of the Rockies are also found in some part of the Pacific Coast region.

The families best represented in the Rock Mountain flora are the following in the order here given: COMPOSITÆ, GRAMINEÆ, PAPILIONACEÆ, CYPERACEÆ, SCROPHULARIACEÆ, ROSACEÆ, CRUCIFERÆ, RANUNCULACEÆ, CICHORIACEÆ, POLYGONACEÆ, ONAGRACEÆ, UMBELLIFERÆ.

In Montana the composites (with CICHORIACEÆ and AMBROSIACEÆ excluded), constituted about 15½ per cent. of the species of flowering plants, the grasses about 10 per cent., the pea family 6 per cent., the sedges and rushes 5 per cent., etc. Of COMPOSITÆ over 45 per cent., of GRAMINEÆ over 41 per cent., and of PAPILIONACEÆ nearly 50 per cent., but of CYPERACEÆ only 25 per cent. are endemic species.

In Montana the following genera are represented by the largest number of species: *Carex, Senecio, Erigeron, Potentilla, Pentstemon, Astragalus, Poa, Aster, Ranunculus, Salix, Artemisia, Polygonum, Castilleja* and *Eriogonum*. In the whole Rocky Mountain region these genera will have nearly the same order, except that *Pentstemon* and *Polygonum* have to be moved slightly further down and *Eriogonum* a little higher in the scale.

P. A. RYDBERG.

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*A TERTIARY CORAL REEF NEAR BAINBRIDGE, GEORGIA.**

THIS fossil coral reef is located near Russell or Blue Spring, about four miles below Bainbridge, Decatur County, Georgia, along the Flint River. My attention was first called to the presence of reef corals in this vicinity by finding two species, collected by Professor Raphael Pumpelly, in the United States National Museum. These species were described by me in Monograph XXXIX. of the United States Geological Survey, under the names *Stylophora minutissima* and *Astrocœnia pumpellyi*, both species being compared with species from the Antiguan Oligocene. Subsequently, in February, 1900, Mr. Alfred H. Brooks, of the United States Geological Survey, brought me from the same locality a species of *Orbicella*, which I identified with an Antiguan species and specimens of *Astrocœnia pumpellyi*. Because specimens of *Pecten* (*Pseudamusium*) *ocalensis* Dall and *Orbitoides* were brought with the corals, I referred the latter to Dall's Ocala horizon of the Vicksburgian Oligocene. It will be shown later that I was mistaken as to the stratigraphic position of the corals.

Because of the interesting character of the corals from Russell Spring, I requested

* Published by permission of the Director of the U. S. Geological Survey.

permission from the Director of the Geological Survey to visit the locality during the present field season.

Three localities where fossil reef corals of the same horizon are found were studied. The best and most important one is on the left bank of the Flint River, about a quarter of a mile below where Russell Spring empties into the river. About a half mile farther down stream on the right bank is another exposure. At Cherry Chute, some three miles below Bainbridge and about a mile above Russell Spring, is another exposure of the same rock on the right bank of the river. The following section was observed at the locality just below Russell Spring and the locality one-half mile farther down stream. It should be stated that the Vicksburgian Oligocene was not seen at the latter locality.

1. Yellow clay and yellow argillaceous limestone, composed largely of comminuted shells, spines of sea-urchins. Fossils fairly numerous, but only a few species are represented; they are a large species of *Orbitoides*, several species of echinoids, *Echinocyamus* is one of the genera, and *Pecten* (*Pseudamusium*) *ocalensis* Dall. The stratum belongs to the Vicksburgian Oligocene. Its upper surface is very irregular, showing decided evidence in favor of Professor Pumpelly's conclusion that the Vicksburg is separated by an erosion unconformity from the succeeding Chattahoochee. Thickness (to water's edge) a few feet.

2. Bluish or whitish sandy clay, sometimes purplish, rarely greenish. In this bed large limonitic segregations are abundant. The segregations occur in pockets often of many feet in horizontal extent and several feet thick. The purplish clay in places contains carbonaceous particles. Thickness variable, from 5 to 10 feet or even more.

3. Cherty limestone, or chert—the fossil coral reef. In the section this does not appear as a connected stratum, but in large detached masses, which very often have rolled down the incline to the river, but some are *in situ*. Dr. Dall identified from this bed for Professor Pumpelly *Orthaulax* and *Amauropsis burnsi*, referring it to the Chattahoochee horizon.* Molluscan remains are abundant, but the state of preservation is poor. The shells are completely silicified, or there are only surface casts or chalcedonic internal fillings. *Pecten*, *Venus*, *Xenophora* and *Natica* are common genera. A very large portion of the rock is composed of coral heads, some more than a foot in diameter. The specimens of corals are more easily removed from the matrix in which they lie than are the mollusks. Thickness, 3 feet.

At Cherry Chute the thickness certainly exceeded 8 feet.

4. Reddish sands, containing some gravel, 8 feet.

The bed of the greatest interest is No. 2. The corals from it belong to the basal portion of the Chattahoochee and not, as I once supposed, to the Vicksburg.

The following is a rough characterization of the corals found in the stratum:

Caryophylliidæ (probably Paracythus)	1 sp.
Other simple corals (several species)	2 or more.
Bifurcating forms	2
Calamophyllia	1
Oculinidæ	1
Stylophora, probably	3
Astrocœnia, probably	2
Orbicella, at least	3
Siderastrea	1
Mesomorpha?	1
Isoporidæ (Madreporidæ Auct.), at least	2
Poritidæ, about	3
Alveopora	1 or more

and several others.

My estimate is that there are between twenty-five and thirty species.

This is the richest fossil coral fauna

* Dall and Stanley-Brown, *Bull. Geol. Soc. Amer.*, Vol. V., 1894. Pp. 151, 152.

known from any one locality of the continental North American Tertiaries. However, the state of preservation of the specimens is not always satisfactory, and it may not be possible specifically to describe all of them.

The particular interest of this fauna does not lie in its richness, but in its geologic import. The Tertiary coral faunas of the United States below the Chipola horizon were very isolated, no species from the continent, excepting the *Orbicella* mentioned, being found in any other area. This fauna is distinctly Antiguan in types. Besides the *Orbicella* referred to, there is a very large-celled *Orbicella*, very close to *O. crassilamellata* (Duncan), if not identical with that species, found abundantly at Russell Spring. An *Astrocœnia* is extremely close to *A. ornata* of Duncan from Antigua. The same remark will apply to the *Stylophora* and *Alveopora*.

From this field examination it appears that the reef corals of the Antiguan marls and cherts can be correlated with the base of the Chattahoochee limestone, the base of Dall's Upper Oligocene. It is also quite probable that the Oligocene reefs in the vicinity of Lares, Porto Rico, and of Serro Colorado, Curaçao, represent the same horizon. The Bowden, Jamaica, fauna would be slightly higher, to be correlated with the Chipola fauna.

It is evident that this coral fauna from Russell Spring, besides filling a gap in the faunal succession on the continent, furnishes a basis for correlating many of the West Indian fossil reefs with the continental Tertiary section, and we may confidently expect more light upon the correlation of American and European horizons.

One interesting feature of these corals, not already mentioned, is that they apparently bring the fauna of Vicksburg, Mississippi, into closer relation with the succeeding faunas. A great deal is shown regarding the succession and interrelations of the faunas of the continent itself.

A fossil coral reef is always interesting, as it reveals in an accurate manner the physical conditions prevailing in a region during a certain portion of its geologic history.

When the material collected has been carefully studied in the office, a detailed account will be published.

T. WAYLAND VAUGHAN.

BAINBRIDGE, GA., Nov. 3, 1900.

PEACH YELLOWS: A CAUSE SUGGESTED.

SOME scientific problems lie beyond the reach of present knowledge, in the sense that they are inaccessible through combinations of known facts or methods of research; in dealing with such matters speculation is permitted full sweep in the hope that some hypothesis may point the way to experimental effort and demonstration. There are, however, other questions to which it seems that ascertained facts should furnish a sufficient clue, though the solution may long elude us. With regard to these, speculation appears to have less propriety, perhaps because we have learned to expect more from increased skill and improved methods of research than from theoretical considerations. But if one of these apparently ripe fruits of knowledge refuses to fall, the efforts of the investigating scientists take on added interest, and the bystanders may become anxious to tell just how it should be done. Thus far these well-intentioned people have not been permitted much satisfaction in connection with the mystery of the peach-yellows, the vigorous and sustained attack by the first investigator, Dr. Erwin F. Smith,* having left untried no theory or method which had been applied in previous studies of

* Dr. Smith's results were finally summarized in Farmer's Bulletin No. 17, U. S. Department of Agriculture, 1894.

plant pathology. Results of great economic value were reached, but the cause has still eluded proof or well-founded suspicion.

And yet after the lapse of a decade interest in peach-yellows has increased rather than abated in the minds of those who witnessed and properly appreciated the original researches. It is true that the wish to repeat any of Dr. Smith's comprehensive investigations would scarcely occur to any one who realized the thoroughness of his methods, but in my experience, at least, every new fact or suggestion which seemed in any way likely to furnish an analogy or other clue to peach-yellows has been carefully scrutinized. During the past summer it has seemed to me to be possible to meet the peculiar requirements of the facts by means of a hypothetical cause, and as this is of a nature such that observation and demonstration may be expected to prove difficult and time-consuming, it seems justifiable to place on record the circumstantial evidence drawn from more general biological considerations, in order that those specially concerned with investigations in this line may have any advantage possible from a suggestion which there is no present opportunity to put to a practical test.

Briefly stated, the proposition is simply that the 'yellows' of the peach may be the result of the poisoning of the protoplasm of the living cells by the bite of a small arthropod, probably a mite of the family Phytoptidæ. The fact that plant cells may be so poisoned by mites as to become yellow and yet retain their vitality for many months, or even for years, was impressed upon my attention while observing a palm of the genus *Thrinax*, which had been infested with the so-called 'red-spider' (*Tetranychus*). That this animal was the cause of the injury was inferred from the fact that the formation of yellow spots ceased as soon as it was exterminated from the plant. This was graphically shown in a young leaf which while still folded was attacked on the exposed lateral segments, where the yellow spots are still distinct, though all other parts are entirely untouched and have remained uniformly green. Discoloration spreading thus from the puncture of an insect or a mite is, of course, no new thing, and is often accompanied by much more serious injuries; moreover, we have all the wonderful phenomena of galls as evidence of the power of animal secretions in profoundly modifying vegetable tissues and structures. The interest of the spots of the *Thrinax* lies merely in the suggestion of a progressive and permanent injury of the tissues without malformation or other striking symptoms. It is true that there is a wide gap between progressive change in a spot less than a quarter of an inch across and one which covers a whole peach tree, but the difference may be one of degree and not of kind, and from the physiological standpoint the galls go far to connect the two extremes. This analogy is especially pointed with the galls induced by inoculation, such as those of the plant-lice and mites, which remain outside the tissues of the host-plant, and yet cause protective malformations.

As the effects of yellows upon the plant tissues could scarcely be thought to be of any advantage to the animal, it may be supposed that no special secretion is involved other than the normal salivary fluid, which might be expected to contain digestive ferments or enzymes,* some of which are now known to exhibit the phenomenon of indefinite self-propagation when brought into contact with substances on which they are capable of acting.

* I am informed by Mr. A. F. Woods that he has for some time entertained an opinion of the enzymotic nature of peach-yellows, drawn from a study of the symptoms of the disease, and from the presence of abnormal quantities of oxydizing enzymes. *Cf. Centralblatt für Bakteriologie, etc.*, 2 Abt., V, p. 574.

Among the important points demonstrated by Dr. Smith, in addition to the absence of any parasitic organism within the tissues, was the communicability of the disease. This fact the present theory amply accommodates, and at the same time does not require insects or mites in large numbers, since the disorder is known to be progressive throughout any tree which has once given evidence of infection. Inoculation by budding from diseased trees also communicates the yellows, a fact which would exclude insect injuries as commonly understood, but which is not inconsistent with the present theory, although the isolation of the deleterious substance or even direct inoculation by the application of the juices and disorganized tissues has thus far failed.*

The presence of an infected tree has been believed to have a distinct effect in inducing the disease in others, though trees will sometimes remain healthy for a considerable period in close proximity or even in contact with those already victims of the malady, and young trees planted in the places of those killed by the yellows are no more liable than others to take the disease. These facts seem peculiarly perverse in connection with a theory of direct infection by a parasitic organism, but become quite comprehensible if the injury be ascribed to mites carried about by bees or by birds; infection would thus be largely accidental, and while the chances would be greater in the neighborhood of diseased trees, no regularity nor continuity in the spread of the disorder need be expected.*

Finally, it was demonstrated by Dr. Smith that neither the character, condition or relative fertility of the soil, nor the age, vigor or variety of the tree has any appreciable influence in predisposing to attack or in securing immunity. Such facts are evidently ample for the exclusion of any hypothesis based on the predication of a constitutional disorder originating independently in the tissues of the trees. The implications point uniformly in the contrary direction, to a definite cause in the form of a specific noxious substance the application of which is followed by a uniform bio-chemical reaction. This inference is not weakened by the fact that the reaction is slow, and that the results of infection become apparent only in new growth from buds or tissues which have been reached by the disease. Thus the first definite symptom of debility caused by infections which may be supposed to have taken place in the spring appears in the premature ripening of the fruits. It has also been noted by Dr. Smith that the degree of prematureness is extremely variable, a fact which seems ex-

* Dr. Smith tells me that *Phytopti* were frequently found by him on yellowed peach trees, and that while the idea that they might cause the disease in the usual manner of parasitic insects suggested itself early in the course of his studies, he rejected it because entirely inadequate to explain the extensive constitutional symptoms which led him to compare the yellows to hydrophobia and smallpox, other communicable diseases of which the causes have resisted investigation. It is true also that the infection phenomena of these diseases appear to include the necessity of inoculating or poisoning cells which remain alive, and from which the disease may be propagated by protoplasmic continuity. Bacteria, on the contrary, are able to pass from one plant cell to another only by breaking down the cell-walls, though the disorganizing effects of their chemical products may precede them.

* The presence of bird's nests may prove to be connected with the not infrequent occurrence of several apparently simultaneous infections in the same immediate vicinity, though not necessarily on contiguous trees. If brought in by small birds it is easy to see that the chances of forming a colony of the injurious mites are many times greater on a tree where a nest is placed, and where the birds spend a large part of their time during the breeding season. Moreover, the well-known persistence of the migratory birds in returning to the same nesting-place would tend to insure a rapid dissemination of the yellows in the year after a colony of the mites had been established in the orchard.

plainable by possible differences in the dates of infection and in the distances through which the disease must propagate itself before it reaches the growing fruit, the normal development of which is inhibited, although the tissues previously formed remain apparently uninjured. The suggestive phenomena of the palm are also capable of a similar explanation, the susceptibility to spotting being apparently confined to the young leaves; otherwise it is difficult to understand why the entire area of the older leaves had not turned yellow long since. The same is likewise true of the leaf-spot or stigmonose of carnations, investigated by Mr. A. F. Woods.*

It can scarcely be expected that many cases completely parallel to the yellows will be found in nature, since parasites which produce such disastrous effects upon their hosts must be unable to maintain extended existence. It is accordingly not to be supposed that the peach is the natural or exclusive habitat of an insect or mite which is able to produce such a disease as peach-yellows. In the biology of galls the localization of the irritant or pathological effect is essential to the establishment of a successful and permanent symbiotic relation, although the possibilities of extensive change through animal irritants are amply shown in the general debility evident in some plants when parasitized by gall-forming insects. These considerations are of special interest in connection with a fact which is of use at least as an analogy, and which may possibly furnish a direct clue to the mystery, since on other plants both galls and hexenbesens have been connected with species of the same group of mites. In a disease of plum nursery-stock reported by Mr. M. B. Waite, one of the prominent symptoms of peach-yellows, the fasciculate branching or hexenbesen formation, was found to be caused by a minute parasitic mite (*Phytoptus?*). In this instance the terminal bud is killed, while the lateral buds in the neighborhood are pushed into premature growth. That this latter development is not caused simply by the death of the terminal bud, but is stimulated by the presence of a noxious compound, is probable, though the disorder is not progressive in the plum, and the removal of the malformed branches permits the resumption of normal growth. The suspicion that the active cause may be similar, if not the same as that of the yellows, is considerably strengthened by the fact that the yellows, while recorded as occurring in almonds, apricots, nectarines and Japanese plums, is not known to affect other sorts of plums. With the supposition of such identity of cause we arrive at the proposition that the mite elaborates in its salivary or other glands an enzyme or other active compound to which the tissues of the peach and closely related fruits are peculiarly susceptible, and which produces in them a permanent and ultimately fatal debility accompanied by definite constitutional symptoms. And that this susceptibility depends on some delicate relation of structure or composition is shown by the fact that the Japanese plums are affected, while the European and American cultivated species appear to stand on the plane of at least partial immunity, being able to resist and recover from the infection. It would thus be possible to accommodate all the related facts in the construction of a complete analogy with the known limitations of many other diseases to groups of related varieties and species.*

* Bulletin No. 19, Division of Vegetable Physiology and Pathology, U. S. Department of Agriculture, 1900. This disease was formerly ascribed to bacteria, but is here shown to be due to the punctures of aphides.

* The force of this analogy is rather strengthened, although its terms may need to be altered, by a fact verbally communicated by Mr. Waite, that a similar dis-

The only novel proposition employed in this hypothetical solution of the problem is that of the indefinite propagation of the pathological effects of a toxic compound of animal origin, introduced in an infinitesimal quantity and of so mild a physiological action as to cause no immediately appreciable damage. And yet the fact of inoculation shows that this requirement must be admitted as far as the internal phenomena are concerned, whatever be the supposed nature of the exciting cause. As already pointed out by Dr. Smith, this phase of the subject has analogy with other abnormal conditions such as variegation of foliage, which in some plants may also be propagated by grafting. But albinism may easily prove to be a composite phenomenon, sometimes constitutional and sometimes induced, and then transmissible. That the albinism theory of peach-yellows is not, however, necessarily inconsistent with that of its origin through mites is indicated by a curious fact for which I am indebted to Mr. H. J. Webber. An albinistic variety of orange, 'Drake's Star,' was found in Florida to be entirely immune to the orange-rust, caused by one of the Phytoptidæ. As albinism, or variegation, is generally admitted to be connected with or accompanied by a lack of vigor, there is the greater warrant for expecting that the present instance of immunity will not prove to be due to any ability to resist the attacks of the mites, but will be found explainable by the absence from the albinistic protoplasm of the compounds affected by the secretions of the *Phytopti*. A definite relation of incompatibility having been established between an albinistic condition and a disease caused by *Phytoptus*, and involving a yellow discoloration of the cells, the physiological analogy between yellows and albinism is strengthened, and the anomalous proposition of an animal poison causing a constitutional plant disease transmissible by budding loses something of its apparent improbability. Further possibilities not unworthy of mention lie in the production of immunity in the peach through inoculation with a less harmful mite, or with a modified enzyme or antitoxine, or with a mild form of albinism, or through the propagation of albinistic varieties. The uniform susceptibility of the sorts now in cultivation in the infested districts renders it extremely improbable that a normal variety able to resist the yellows could be secured by selection or introduction from abroad.

A further biological reason for belief in a definite external cause for peach-yellows is to be found in what may well be considered a second species of the same genus, the so-called 'peach-rosette,' which has appeared in the orchards of Georgia and as far west as Kansas. This disorder is of a much more virulent type than the yellows, and is able to attack and destroy the plum. It has distinctly different, though similar, symptoms and is likewise contagious and communicable by budding. With two such diseases occupying reasonable definite geographic areas and both repeatedly occurring sporadically within wide general limits, the probability is greatly increased that we are dealing with the injuries of two species of *Phytoptus* or related mites which are normally parasitic on native vegetation, probably indigenous species of *Prunus*, whence they are accidentally transferred to the peach and related fruits of foreign origin, supposably by bees or by birds. Such a method would explain the many independent reappearances of the diseases, and their capricious distribution in orchards, where contiguity or even contact

order of peach nursery stock has also been traced to a mite, even though it may be found that the animal is of a species different from that of the yellows. Neither can we as yet exclude the possibility that the peach may be less susceptible when young than after it has reached bearing age.

has sometimes been found to have little or no effect in facilitating transmission. The facts which have been taken to indicate a gradual spread of the diseases, and thus have been used as an argument for an epidemic type of infection, are as well or even better provided for in the above suggestion, if proper allowance be made for the fact that such diseases are brought to the attention of pathologists only when they threaten serious damage to commercial interests in the hands of intelligent horticulturists. This would be by no means the first instance where the extension of our knowledge of a disease has been interpreted as an extension of the disease itself. As with most other plant diseases, neither the yellows nor the rosette was recognized as a definite malady until an organized industry was attacked. Both were at first supposed to be local, and though a wide distribution has been ascertained, there is nothing to indicate that either was introduced from Europe or has spread to California, facts which also militate strongly against theories of the constitutional origin of the diseases, though possibly comparable with the failure of the above-mentioned orange-rust mites to establish themselves in the dry atmosphere of California.

That the yellows has not gone south and that the rosette has not come north are also indications that the diseases are not spread entirely from the peach, if we admit that both disorders had probably existed for many decades before their scientific recognition. In fact, the various considerations of distribution are sufficient to warrant a belief in local origin and external infection, and it is not even necessary to insist that they are transferred in nature from one peach tree to another, since the existence of the injurious species in the neighborhood of an orchard would mean that infection might be indefinitely repeated. It is also to be remembered that under the theory of infection of an entire tree by a single puncture it is to be expected that there will be many trees with yellows where none of the injurious mites can be found, since only when fertilized females or both sexes are transferred will the species be multiplied. Thus might the yellows be 'contagious' from some trees, where colonies are formed, while not contagious from others.

But though the mite should be found to breed upon the peach, insecticides would remain useless, since the infected trees are injured beyond repair and may as well be removed and burned, as Dr. Smith has urged. That this policy has appeared to keep the yellows in check in some parts of Michigan may mean that either our supposititious mite or the agent of its transfer to the peach is locally rare. We have, in fact, all gradations from an apparent epidemic in some parts of the East to a merely sporadic condition in Illinois, where competent investigators are not yet convinced that the disease is contagious.

It is a fact well known to entomologists that the numbers of many species of insects and other short-lived arthropoda vary enormously in different years or periods of years. An unfavorable season, an active enemy, or a disease may reduce a species to practical non-existence for a time, until the return of favorable conditions permits a gradual increase to the former numbers, or even to unrecorded abundance. These fluctuations are also closely comparable with those which appear in connection with parasitic fungi and bacteria, species previously so rare as to have remained quite unknown to the botanist often appearing suddenly as the agents of extensive injury. Seasonal and periodic as well as local differences in the apparent 'virulence' of peach-yellows would thus be readily explainable on the present theory, to which plant pathologists need not object because of reasons drawn from the history of the malady.

A permanent solution of the problem on these lines may be postponed by the fact that, notwithstanding their well-known economic importance, the Phytoptidæ remain a little-known group, even from the systematic standpoint, doubtless owing to their excessively small size. But if the present hypothesis should prove to have any basis in fact, it will probably be possible to control or even to exterminate the yellows by the local destruction of the wild relatives of the peach which may be found to harbor the offending creatures. The extent to which this would be necessary for the protection of peach-orchards will depend upon the agency of transmission. Fortunately the mites are without wings, and whether carried by small birds or by insects, the distances whence they would ordinarily be brought are not great. There is thus opened another possibility, at least, of the relief of this important industry from the ravages of maladies which not only cause thousands of dollars of damage annually, but which are chargeable with a further public injury in limiting the production and popular enjoyment of this finest of temperate fruits.

O. F. COOK.

WASHINGTON, D. C.

SCIENTIFIC BOOKS.

Leçons de chimie physique. Professées a l'Université de Berlin. Par J. H. VAN'T HOFF, membre de l'Académie des Sciences de Berlin. Professeur ordinaire a l'Université, et directeur de l'Institut de Physique de Charlottenbourg. Ouvrage traduit de l'allemand par M. COEVISY, Professeur agrégé au Lycée de Saint-Omer. Paris, Librairie Scientifique, A. Hermann. 1899.

The book in hand is a French translation of Van't Hoff's lectures on 'Selected Chapters in Physical Chemistry' which he now delivers at the University of Berlin. As the title implies, the book is not a systematic treatise on the whole subject of physical chemistry, but the number and importance of the subjects dealt with are so great that the scope of the work is not small.

The order of arrangement is quite different from that usually adopted. It is the general custom to take up first the older work in physical chemistry which has to do with the relations between composition and physical properties, and constitution and physical properties. This is then followed by the newer physical chemistry, dealing with solutions and energy transformations in the broad sense; concluding with chapters on chemical dynamics and chemical statics.

Van't Hoff has, indeed, exactly reversed this order. Part first is on Chemical Dynamics, including chemical equilibrium and reaction velocity. Part second, on Chemical Statics, contains chapters on molecular weights, molecular structure and molecular grouping; and it is not until the third and last part of the book is reached that we find a discussion of the relations between properties and composition; comprising relations between physical properties and composition on the one hand, and chemical properties and composition on the other.

In those who have been accustomed to the older order of things this new order of presentation produces a little discord. This, however, may not argue against the method adopted by Van't Hoff. It should, nevertheless, be noted in this connection that the more generally accepted order of presentation is far more closely in accord with the historical development of the subject, and there are those who believe in the pedagogical value, at least, of the historical method.

The newest work of Van't Hoff, like everything which he has written, is full of original and brilliant suggestions. There is hardly a subject touched, in the whole book, without new light being thrown upon it and new relations pointed out. No one can read the work without feeling that physical chemistry is here treated by a master hand, which not so much compiles as creates.

These lectures are, for the most part, rather advanced, as we should naturally expect them to be. They should, therefore, not be placed

in the hands of a beginner. To any one who has mastered the elements of physical chemistry this book is indispensable, and it should be read by all who desire to keep abreast with the newest and best which has appeared in the field of general chemistry.

H. C. J.

Determination of Radicles in Carbon Compounds. By Dr. H. Meyer, Docent and Adjunct of the Imperial and Royal German University, Prague. Authorized translation by J. Bishop Tingle, Ph.D., F.C.S., Instructor of Chemistry at the Lewis Institute, Chicago, Ill. New York, John Wiley & Sons; London, Chapman and Hall. 1899.

This English edition of Dr. H. Meyer's 'Anleitung zur quantitativen Bestimmung der organischen Atomgruppen' will be heartily welcomed by all teachers and advanced students in organic chemistry. As the translator well says in his preface: 'The quantitative side of organic chemistry, apart from elementary analysis, is almost always neglected in the ordinary courses of instruction, and when the need for it arises, in the prosecution of research work, for instance, it is difficult to obtain a comprehensive view of the methods which are available without undue expenditure of time.' The present work supplies a systematic treatment of the various methods in use for determining quantitatively most of the groups ordinarily found in carbon compounds in a very convenient and compact form. It is to be hoped that it will bring about the introduction of some quantitative work into the regular college course of organic preparations. Some idea of the character of the book may be given by the following brief synopsis of its contents. The book is divided into five chapters. Chapter I., which is introductory, treats of the determination of hydroxyl (—OH); Chapter II. of methoxyl (CH_3O—), ethoxyl (C_2H_5O—), and carboxyl (—COOH); Chapter III. of carbonyl; Chapter IV. of the amino and related groups and Chapter V. of the diazo-, hydrazide-, nitro-, iodoso- and iodoxy-, and the peroxide-groups. The author has made various corrections and additions to the English edition, so that it is an improvement on the German one. The book is well printed and bound in convenient form for laboratory use. It has a good index of both subjects and authors' names, and an appendix containing some useful tables. The book can be most heartily recommended to all organic chemists.

W. R. Orndorff.

SCIENTIFIC JOURNALS AND ARTICLES.

In *The American Journal of Physiology* for November, J. C. Herrick reports an investigation of the influence of temperature on nervous conductivity. He found that a strong or moderate action current produced by an induction current or condenser discharge was not changed in intensity when the nerve impulse passed through areas varying in temperature from 8° C. to 40° C. Usually a decrease in current followed the application of temperature beyond these limits. An increase in the strength of action current in passing the impulse through a warmer area occurs, however, under two conditions—when the action current is only a small fraction of the maximum, and when the entire nerve except the warmed part is below 10° C. From his observations he concludes that the action current ordinarily observed and studied probably lies far beyond those accompanying maximal functional impulses.

Porter and Muhlberg present an experimental criticism of the theory that injury produces prolonged inhibition of the activities of the spinal cord. Believers in automatism of the cord have explained the failure of the cord to continue orderly functioning after separation from the brain, by assuming that the conditions of experimentation inhibit the spinal centers for a long period. To settle the question, the cell bodies of the respiratory nerve of the diaphragm were separated on one side of the spinal cord from the respiratory center in the brain. After this was done, these cells were still able to discharge motor impulses, but their apparently automatic rhythmic respiratory power was gone. Animals kept for a long period after this operation proved that the loss was permanent, and that it could not, therefore, be ascribed to inhibition.

Artificial division of egg cells, now attracting so much attention, has been further investi-

gated by A. P. Mathews, who presents the results of observations on Arbacia eggs. Mathews found that karyokinetic nuclear division followed by cell division may be produced by lack of oxygen, by heat and by exposure to ether, alcohol and chloroform. Since all the methods which induced karyokinesis in these eggs are well-known methods of causing liquefaction in protoplasm, Mathews suggests that the essential basis of karyokinetic cell division is the production of localized areas of liquefaction in the protoplasm.

S. I. Franz's paper, 'On the methods of estimating the force of voluntary muscular contractions and on fatigue,' is largely a destructive critique of the methods hitherto employed for determining muscular ability. With a weight ergograph or with an ordinary spring ergometer two variables are always present—the force and the extent of a contraction. These two factors are so variable in different individuals that accurate comparison of relative muscular ability is impossible. A third variable in the use of these instruments is noted in the nutrition changes of the working muscle. The isometric use of a spring is recommended because the main factor in an investigation of fatigue—muscular force—is practically isolated. The results of fatigue experiments show that after 150 maximum contractions the muscle can accomplish about 40 per cent. as much as it could at the beginning of the series. A large daily variation in results is noted. This factor, which has been almost wholly neglected in previous researches, indicates that the conclusions of early investigators should be held only until they can be investigated further.

THE *American Journal of Insanity* for June, in addition to the articles noted in our last issue, contains a paper by Dr. F. Savary Pearce, of Philadelphia, who presents 'Further Laboratory Studies on Uric Acid in Neuræsthenia and on Auto-intoxication in Nervous Disease,' in which he says: "We have sufficient data to say positively that neuræsthenic conditions are associated with the circulation of such an irritant in the blood. From the observations of Haig, it seems clearly proved also that when the uric-acid elimination is decreased, the urea elimination is normally increased. The amount of elimination of urea is in proportion to the albuminous food products properly absorbed into the blood, thus giving rise to strength and a feeling of latent vigor in the system so nourished. On the other hand, there assuredly follow a sense of feebleness and lack of resistance when the uric-acid elimination goes above the normal and, in consequence, the urea elimination falls. In 'Degeneracy' Dr. O. Everts, of Cincinnati, calls attention to the fact that the term degeneracy is without uniformity of meaning or restricted definition. He regards degenerates as "all persons who by reason of mental deficiency are incapable of self-support, as well as those who by reason of mental deficiency are incapable of perceiving the sinfulness of sin or the beneficence of restraint therefrom." He believes degeneracy to be an inevitable sequence of civilization without any hope of remedy. Dr. W. L. Worcester, of Danvers, Massachusetts, presents 'Three Cases of General Paralysis in Young Women' together with the pathological findings at the autopsies. One of these cases was a young mulatto. Dr. Charles E. Woodruff, of the U. S. Army Medical Corps, has a paper entitled 'Degenerates in the Army.' He finds that few of these degenerates in the army present the characteristic stigmata of degeneration, a fact which he believes to be due to the rigid examination to which all recruits are subjected upon enlistment. Degenerates in the army come from the borderland of partial degeneracy, the criminaloids of Lombroso. Some are cases of slow development—partial infantilism—who have run away from home in search of adventure, but more are mild types of the neuræsthenic tramp, restless, unstable and flitting from one employment to another. They are unable to endure monotony of army life with its rigid discipline and are generally deserters.

The Journal of Comparative Neurology for October contains the following articles: 'A Contribution upon the Cranial Nerves of the Cod Fish,' by C. Judson Herrick, with 2 plates; 'Notes on Professor Judson Herrick's Paper on the Cranial Nerves of the Cod Fish,' by F. J. Cole; 'Further Observations on the Conditions determining the Number and Arrangement of the Fibers forming the Spinal Nerves of the

Frog (*Rana virescens*),' by Irving Hardesty. 'Anastomosis of Nerve Cells in the Central Nervous System of Vertebrates,' by N. Worth Brown, with plate; 'A brief Summary of the Researches of Theodere Kaes on the Medullation of the Intra-cortical Fibers of Man at different Ages,' by Helen Bradford Thompson; 'Book Notices.'

THE *Botanical Gazette* for November contains an important paper, by Burton E. Livingston, of the University of Chicago, on the nature of the stimulus which causes the change of form in polymorphic green algæ. The form used was a species of *Stigeoclonium*, and it was made to assume the spherical or filamentous form and to organize zoospores or not at will. The evidence seems perfectly clear that the responses, both in form and reproductive activity, are due to changes in the osmotic pressure of the medium and are in no way functions of its chemical composition. A high osmotic pressure decreases vegetative activity, inhibits the production of zoospores, causes cylindrical cells to become spherical, and frees the alga from certain limitations as to the orientation of planes of cell division, while a low pressure has the diametrically opposite effect in each case. Professor Conway MacMillan publishes some careful observations upon the structure of *Lessonia*, one of the huge Laminaria forms. The material studied was cast up upon the beach of Vancouver Island. Mr. C. D. Beadle, of the Biltmore Herbarium, describes ten new species of *Cratægus*. Mr. John F. Cowell, Director of the Buffalo Botanic Garden, gives an appreciative biographical sketch, with portrait, of the late David F. Day. Mr. Carleton E. Preston, of Harvard University, records some field observations as to the root system and vegetative propagation of Cactaceæ.

Popular Astronomy for December has for a frontispiece the New Allegheny Observatory, whose corner stone was recently laid. The address delivered upon this occasion by J. A. Brashear is given in full, as well as notes descriptive of the corner stone exercises and the building itself. Another topic of interest to general readers is that of the *Leonid Meteors* watched for last year and this. Professor W. W. Payne discusses their orbit, and the results of the observations made at various points this year are noted and charted. Kurt Laves' practical help on the 'Adjustment of the Equatorial Telescope' is continued in this number, and Charles P. Howard's paper on the 'Total Eclipse, of May 28, 1900,' is begun. E. S. Holden writes, 'Among the Stars,' and S. W. Burnham contributes two short articles on double stars. Many brief reports of the Eros observation work are included in the general notes, which, with the usual Spectroscopic, Planet, Comet, Asteroid notes, completes the last number of the volume for 1900.

SOCIETIES AND ACADEMIES.

GEOLOGICAL SOCIETY OF WASHINGTON.

THE 104th regular meeting was held at the Cosmos Club, November 14, 1900.

The following papers were presented:

'Notes on Lake Chelan and Vicinity,' by Mr. Bailey Willis.

The Cascade Mountains of Washington State constitute a plateau, so thoroughly dissected, however, that none of the original surface remains. The greater number of the resulting sharp peaks and ridges have summits close to an imaginary sloping plane ranging in altitude from 3,000 to 8,000 feet. The initial uplift was succeeded by development of moderate relief, followed by the last and principal elevation. It is not yet known whether this final uplift is late Pliocene or early Pleistocene. Lake Chelan lies in an area of metamorphic and igneous rocks, the oldest of which are schists of sedimentary origin. They are cut by younger granitic rocks. These in turn are traversed by dikes of andesite, diorite porphyry, and acid quartzose porphyries.

'Remarks on Troost's Geological Map of the Environs of Philadelphia, 1826,' by Mr. G. P. Merrill.

A copy of this rare map, which the Marcous, in their catalogue of geological maps of North America, state is unknown, was exhibited to the Society.

'Ore Deposits at Monte Cristo, Washington,' by Mr. J. E. Spurr. Among the rocks of the Monte Cristo district are arkoses and

quartzites, and a variety of volcanic rocks, comprising andesites, rhyolites, dacites and basalts. There were two periods of andesitic eruption. The arkoses and the older andesites which are among the most ancient rocks, are cut by large dikes of tonalite, which have altered the intruded rocks near the contact to quartz, biotite, garnet and staurolite schists. Strong, steeply dipping, jointing or sheeting is one of the latest geologic structures, and accepting the principal uplift of the range as late Pliocene, the jointing is probably not older. Along these joints most of the ore deposits have formed. The ores consist chiefly of arsenopyrite, chalcopyrite, phyrrhotite, pyrite, blende, galena and some less important sulphides. The deposits occur mainly in the tonalite and to a less extent in the older andesites, occasionally in the other rocks.

'The Mother Lode, folio, California,' by Mr. F. L. Ransome.

This special mining folio No. 63 of the Geologic Atlas of the United States was shown and its scope briefly outlined. It deals with an area six and a half miles wide and seventy miles long, embracing the greater portion of the so-called 'Mother Lode' system of gold-quartz veins.

'Paleobotanical Aspects of Some Upper Paleozoic Formations of Nova Scotia,' by Mr. David White.

A brief *résumé* of the correlations by stratigraphy on the one hand with the correlations by paleontology on the other hand. The Horton and the Riversdale plant beds, which are referred by the Nova Scotia geologists to the Hamilton, are, on the evidence of the fossil plants, referable to two stages; the Horton being Pocono and in the basal portion of the lawn Carboniferous, while the Riversdale plants indicate a stage for these at or near that of the Pottsville.

F. L. RANSOME,
DAVID WHITE,
Secretaries.

NEW YORK ACADEMY OF SCIENCES.

SECTION OF BIOLOGY.

THE regular monthly meeting November was held on the evening of November 12th, Professor C. L. Bristol, presiding.

The following program was offered:

F. C. Waite, 'The Bermuda Toad' (to be published in full in SCIENCE).

H. F. Osborn, 'The Phylogeny of the Rhinoceroses of Europe.'

H. L. Clark, 'Further Notes on Bermuda Echinoderms.'

Professor Osborn reported a continuation of his investigations upon the 'Phylogeny of the Rhinoceroses of Europe.' These animals appear to fall under the law of early divergence, and to constitute at least six separate series or phyla, which, so far as known at present, are not genetically related to each other, but undergo a more or less parallel development, as follows: Diceratheriinæ, Aceratheriinæ, Brachypodinæ, Ceratorhinæ, Atelodinæ, Rhinocerotinæ. The chief criteria in distinguishing rhinoceroses are the proportions of the skull, whether dolichocephalic or brachycephalic, the proportions of the limbs in reference to cursorial or aquatic habits, and the position of the horns; subsidiary to these features are the types of tooth structure. The origin of the Rhinoceroses is still obscure, although it appears to be possible to derive the Diceratheriinæ from certain Eocene Hydracodontidæ.

This study will be published in full in the *Bulletin* of the American Museum of Natural History, and it constitutes a part of the continuation of the author's memoir on the extinct Rhinoceroses.

Mr. H. L. Clark's paper was read by Professor C. L. Bristol. In this paper Mr. Clark gave an account of the Echinoderms collected by the party of zoologists from the New York University in the summer of 1899, together with a summary of his own observations during April of that year. It is to be concluded from an abundance of observations that the distinctions hitherto thought to exist between *Stichopus diaboli* and *acanthomela* are not to be regarded as valid, and the forms described under these names must be referred to *S. Möbii*. Twenty-nine species are listed.

Mr. Waite called attention to the fact that the madreporic body in *Asterias tenuispina* branches, forming 1–4 bodies in each animal, thereby making orientation difficult.

F. E. LLOYD, *Secretary.*

TORREY BOTANICAL CLUB.

At the meeting of the Club on October 31st, Dr. P. A. Rydberg read a paper on 'The Melanthaceæ of the Rocky Mountains.' Numerous herbarium specimens were exhibited, including the types of seven new species described by Dr. Rydberg in the *Torrey Bulletin* for October. To these descriptions he now added further particulars regarding habit, distribution and critical characters, presenting also a series of comparative drawings of their petals and sepals. One of these new species of especial interest is *Veratrum speciosum*, to which most of the specimens previously ascribed in herbaria to *V. Californicum* prove to belong. The presence of conspicuous petioles at the lower leaves of typical *V. Californicum* was demonstrated from the type-specimen and also by explicit accompanying statements by Dr. Asa Gray, whose manuscript description was produced.

Edward S. Burgess,
Secretary.

ZOOLOGICAL JOURNAL CLUB OF THE UNIVERSITY OF MICHIGAN.

The first meeting of the club was held November 1st. Dr. S. J. Holmes reported the results of work done at Woods Holl during the past summer on the habits and natural history of *Amphithoe longimana* Smith. The observations made were upon the movements of the animal, food, nest-building and instincts associated with living in nests, moulting, color changes, the seat of smell and the instincts of the young.

Mr. L. J. Cole gave an account of work done at Woods Holl during the past summer on the habits of *Pycnogonids*. Most of the notes were based on observations of *Anoplodactylus*, though *Tanystylum* and *Pallene* were studied also.

Crawling and Swimming Movements.—The action of the legs in crawling and in swimming was analyzed and was found to be exactly the same in the two cases. When the stroke of the legs is strong enough to lift the animal from the bottom, swimming results; otherwise the same movement produces crawling along the bottom. The stroke of all the legs is the same except that it is stronger in the anterior legs, and this is what carries the animal forward in crawling, rather than backward. The action of the posterior legs is an actual hindrance in crawling.

Reactions to Light.—1. Both *Anoplodactylus* and *Pallene* show strong positive phototaxis. In going towards the source of light *Anoplodactylus* may either crawl or swim, being oriented differently in the two cases:

2. In crawling towards the light the animal progresses forward. If not oriented in this direction at first it becomes so oriented by making a short circle in every case towards the light.

3. When an animal walks in a circle those legs on the outside must make a more effective stroke than those on the inside, which means in this case that *those legs away from the light beat stronger than those towards the light.*

4. In swimming towards the light the animal progresses approximately *backward* with the anterior end somewhat raised, the amount depending upon the activity of the individual and the slant of the rays of light.

5. This orientation is brought about by the actions previously mentioned: (*a*) The stronger action of the legs on the side away from the light raises that side, and the animal consequently travels toward the light; (*b*) The stronger action of the anterior legs, as compared with that of the posterior, tends to bring the anterior end of the animal into the upper position, giving the orientation described.

Transfer of the Eggs from the female to the ovigerous legs of the male.—When first observed the male was clinging to the dorsal surface of the female and headed in the same direction. The basal joints of the legs of the female were approximated below with a mass of eggs between. The male crawled around over the anterior end of the female, coming into such a position that their ventral surfaces were together and their heads in opposite directions. The ovigerous legs of the male hooked into the mass of eggs, and as the animals separated carried them away. Fertilization presumably took place at the same time.

At the second meeting, November 8th, Dr. S. J. Holmes presented an account of work done during the past summer at Woods Holl on Phototaxis in Amphipods.

Most of the experiments were performed on

two species of Orchestidæ found at Woods Holl, Mass., *Talorchestia longicornis* and *Orchestia agilis*. *Talorchestia* was found to be positively phototactic at all times both in strong and in weak light. *Orchestia agilis* is somewhat less strongly positive since, for a short time after it is taken from the dark, it becomes negatively phototactic, but exposure to the light soon makes all the individuals strongly positive and they remain so even in direct sunlight. Both these species when exposed to direct sunlight remain positively phototactic until overcome by the heat of the sun. Yet the animals when they come to rest are found in shaded spots and, during the daytime, remain unexposed to the light; they are photophobic, but positively phototactic. Observations were made on twenty-two species of aquatic amphipods, all of which were found to be negatively phototactic. It was found that when the terrestrial *Orchestia agilis* were thrown into sea water their phototaxis immediately changed from positive to negative; when taken out of the water the reverse change occurs, and this change was shown to be independent of temperature.

Orchestia agilis, when brought from strong light, in which it is strongly positive, to weak light, immediately becomes strongly negative, a result which, it is believed, has been observed in no other form. When left in weak light the negative phototaxis disappears and all the specimens become positive again. This result was shown to be independent of temperature. Specimens rendered negative by being brought into a dimly lighted room after exposure to strong light become positive more quickly if the temperature is raised. Exposure to darkness or to very strong light renders *Orchestia agilis* temporarily negative in light of medium intensity.

In *Talorchestia*, *Orchestia*, and several species of insects that are positively phototactic it was found that, when one eye is blackened over, the animal travels in circles with the unblackened eye looking towards the center. In several negatively phototactic forms blackening one eye was found to produce circus movements in the other direction, the unblackened eye looking away from the center. *Orchestia agilis* may be caused to execute circus movements in the one or the other direction according to whether it is placed in air or water.

H. S. JENNINGS,
Secretary.

DISCUSSION AND CORRESPONDENCE.

THE ELECTRICAL THEORY OF GRAVITATION.

PROFESSOR FESSENDEN in a recent number of SCIENCE discusses the nature and velocity of gravitation. There is, no doubt, something of value in Professor Fessenden's suggestions and much that is new. However, the explanation of gravitation which Professor Fessenden offers is by no means so adequate as would appear from Professor Fessenden's discussion.

In the first place, *Quantitative Mathematics*, as Professor Fessenden styles his papers on Dimensions, has little or nothing to do with the thing. The present writer makes this statement not entirely as an expression of his own opinion, but quite as much as an expression of opinion of every physicist with whom he has talked on the matter. Professor Fessenden claims to have derived *numerical functional relations*, with the aid of his 'Qualitative Mathematics,' and this is believed on definite rational grounds by most physicists to be impossible.

One of the best examples of the application of 'Qualitative Mathematics' is its application by Lord Rayleigh (*Philosophical Magazine*, October, 1899), in his 'Investigation on Capillarity.' In this instance the weight of a drop of water falling from the end of a glass tube is shown to be a certain function of radius of tube, density of water, acceleration of gravity and surface tension of water *multiplied by an unknown function of these quantities having zero dimensions in length, mass and time.* This unknown and unknowable function—to be determined by experiment only—Fessenden seems to lose sight of in his 'Qualitative Mathematics.' The reader who wishes to get the gist of Professor Fessenden's suggestions as to the nature of Gravity may therefore, as it seems to us, ignore what he says of, and is led to say by 'Qualitative Mathematics.'

The following is a brief and fairly simple outline of the electrical hypotheses which are now held by physicists in the attempt to explain the ultimate constitution of matter and the nature of inertia and of gravitation.

Electrically charged bodies are of two kinds, namely, positive and negative. Like charges repel and unlike charges attract. The energy associated with two charged bodies is seated in the ether which surrounds the two bodies and is due to the electrical field or ether stress. When *unlike* charges approach, the energy of the ether stress diminishes and the outside work done by the attraction of the charges is equal to the diminution of the energy of the ether stress. Similarly, the energy of ether stress, which is associated with two *like* charges, increases when the charges are pushed towards each other and the increase of the energy of the ether stress is equal to the work done in pushing the two charges nearer together.

In general, attraction of two bodies is to be attributed to ether energy, which *decreases* as the bodies approach each other, and repulsion of two bodies is to be attributed to ether energy, which *increases* as the bodies are made to approach each other. Physicists have known this many years and, as regards gravitation, no satisfactory clue has yet been found concerning the nature of the accompanying ether energy and concerning its mode of propagation from place to place.

It is now pretty well established, that the ether energy having to do with electrical attraction and repulsion is dependent upon a sort of *shearing distortion* of the ether unaccompanied by any sensible diminution of volume, that this ether distortion is what is known as *electric field*, that the propagation of this energy constitutes *electrical waves*, and that the movement of the ether which comes into play during the establishment of this shearing distortion, or which comes into play while distortion at one place is relieved and distortion at a contiguous place is built up, is what is known as *magnetic field*.

It may be that the ether distortion which we call electrical field is accompanied by a very slight diminution of volume of the ether, especially inasmuch as Maxwell showed that the mechanical stresses in the dielectric tend to produce diminution of volume as well as to produce shearing distortion. These mechanical stresses are proportional to the square of the field intensity at each point.

If we admit that the diminution of volume of the ether at each point is proportional to the resultant intensity of the electric field, then the part of the energy which depends upon diminution of volume cannot be separated in its effects from the part of the energy which depends upon the shearing distortion, inasmuch as both are proportional to the square of the resultant field intensity. Therefore a diminution of volume of the ether could not explain gravitation, but would only be involved in the explanation of ordinary electric attraction and repulsion. Professor Fessenden in his article above referred to speaks quite in general of the compression of the ether near a charged body (or ion) without localizing this distortion.

Before proceeding to a statement of what must constitute the characteristic features of an explanation of gravitation, as opposed to an explanation of electric attraction and repulsion, for the reader will certainly think of an explanation of the one as applying satisfactorily to the other also, so far as the above discussion goes, it is necessary to outline briefly the present hypothesis that the inertia of an atom, or rather that the inertia of a corpuscle, is due to its electric charge.

It has been known for some years that a moving electrically charged body has more kinetic energy for a given velocity than if it were not charged; that is, the acceleration of a charged body by a given force is less than if the body were not charged; that is, the inertia of a charged body is greater than if it were not charged. This excess of energy of a moving, charged body—for the whole matter lies in the question of energy—is due to two things, as follows:

First, The dying away of the electric field in regions passed through by the body and the building up of electric field in regions newly reached by the body is accompanied by an ether motion known as magnetic field, as above stated, and this magnetic field represents energy.

Second, The motion of a charged body tends to concentrate the electrical field or ether stress in and about a plane passing through the body and at right angles to the direction in which the body is moving. This concentration of the electric field causes, on the whole, an increase in the total energy of the electric field.

A curious fact, assuming the truth of the following hypothesis, is that the energy of a moving body is *not* proportional to the square of its velocity, but exceeds this by an amount which becomes infinite when the body attains the velocity of light, although this excess of energy at ordinary velocities is exceedingly small. If it were not for the tendency of electrical field to become concentrated in a certain plane as described above, the energy of a moving body would be strictly proportional to the square of the velocity, assuming the truth of the hypothesis which is now to be stated.

The excess inertia due to the electric charge on a body, or briefly, the inertia of the charge is greater and greater the smaller the body. Atoms, however, are not small enough for us to attribute *all* their inertia to the charge which they carry when they are in the form of ions. The corpuscles, of which J. J. Thomson builds an atom like a bricklayer builds a house, and to the hypothetical existence of which Thomson was led by the study of cathode rays, are perhaps small enough.

The electrical hypothesis of the constitution of matter, is that atoms of matter are built up of corpuscles, and that these corpuscles are mere bits of electric charge, some positive and some negative surrounded by electric fields, or rather that these corpuscles are mere strain centers in the ether surrounded by regions of ether stress.

This hypothesis of the constitution of matter serves well for the interpretation of the perplexing class of phenomena attending the discharge of electricity through gases and it explains that fundamental property of matter, inertia.

Now we have two distinct measures of mass, namely: One body is said to be twice as massive as another, or to contain twice as much matter, when it is *accelerated* at half as great a rate by the same force or when it is *attracted* by the earth or any third body by twice as great a force. The first measure of mass is sometimes called inertia and the second is often, in daily life, called weight, and it is remarkable that these two measures agree with each other to a great degree of precision. One might expect, therefore, that an hypothesis as to the constitution of matter which clears up the nature of inertia, even provisionally, would throw some light upon the nature of gravitation, but it does not seem to be so, and Professor Fessenden must needs say more from his point of view and with greater precision before we shall be convinced. The difficulty to be encountered in the explanation of gravitation from the point of view of the electron hypothesis, as Johnstone Stoney calls it, seems to be as follows:

Imagine all corpuscles to consist of equal positive or negative charges, this indeed is assumed by J. J. Thomson, the only present need of this assumption is to permit of simple statements. Then, if those approximate facts which we call the laws of electrostatics were true, Newton's law of gravitation (?) would have to do only with *electric attraction and repulsion*, and it would run thus: every corpuscle of matter in the universe attracts or repels every other particle with a force which is inversely proportional to the square of the distance between them.

Two opposite charges may be said to be equal in value when they are acted upon by equal and opposite forces when placed in a uniform electric field. Now if two such charges of opposite sign attract each other with a slightly greater force than the force of repulsion of two precisely equal charges of the same sign, then two aggregations of equal numbers of positive and negative corpuscles would on the whole attract each other, because the oppositely charged corpuscles in the two aggregations would attract each other a little more than the similarly charged corpuscles would repel. Thus gravitation would be due to the fact that the *attraction* of equal and opposite charges would be slightly greater than the *repulsion* of like charges of the same value. This inequality of attraction and repulsion of equal charges would exist if the relation between stress and strain in the ether were not a linear relation, that is, if ether strain were not proportional to ether stress, for in the case of opposite charges the ether stresses are on the whole more intense and less widely distributed than are the ether stresses in case of two like charges of the same value at the same distance apart. It would be a comparatively simple matter to determine the amount of deviation from proportionality of stress and

strain which would suffice to account for gravitation. But the outstanding difficulty would be to explain the high velocity of propagation of gravitation which seems to be required by the known behavior of the solar system under the action of the sun's gavitation.

Of course it may be that the failure of the linear relation between ether stress (electric field) and ether strain is associated with ether compression, and it might be possible to explain in this way the high velocity of the propagation of gravitation. The point, however, which we wish to emphasize is that mere ether compression alone is not sufficient to explain gravitation; at least the compressional energy must not be proportional simply to the square of the resultant field intensity, for in this case the compressional energy would not be distinguishable from the distortional energy which gives rise to the ordinary electric attraction and repulsion. If, however, the compressional energy were proportional to the fourth power of the resultant field intensity, then the ether compression would not stand in a linear relation to electric field intensity (ether stress), and the above remarks concerning excess of the electric attraction over repulsion would apply and gravitation would be provisionally explained.

W. S. Franklin.

THE HOMING INSTINCT OF A TURTLE.

To the Editor of Science: The following account from a friend, Miss Victoria Hayward, of Bermuda, may be of interest to your readers. I can vouch for the accuracy of the relater, and know from experience that the locating of an area on the reefs is as easy to a Bermudan as if it were on dry land. Miss Hayward writes:

"My father caught a turtle in June that weighed seventy-five pounds. He placed it in a pond in the harbor of St. George. In August on going to the pond he found that some person had thrown a piece of iron weighing about fifty pounds into the pond and it had broken a large hole in the turtle's back. It had been wounded apparently about a week and was weak and seemingly dead. My father thought he had better kill it, but he changed his mind, and let it go alive into the harbor.

"In the latter part of October he and another man recaptured it in the same place where they had caught it before—about four miles from land, on the flats (reefs) that lie to the north of the islands. The back was nicely healed and the turtle was altogether in excellent condition. You know that it requires no little knowledge of the art of navigation for a turtle to find the way from the southern side of St. George's Harbor through some one of the many little channels to its own special home on the north reefs—four miles out to sea."

C. L. Bristol.

BOTANICAL NOTES.

PEACH LEAF CURL.

According to a bulletin (No. 20) prepared by N. B. Pierce and recently issued by the Division of Vegetable Physiology and Pathology of the United States Department of Agriculture, this disease appears to exist wherever the peach is grown. It is known to occur in North America, South America, Europe, South Africa, New Zealand, Australia, Japan and China. It is due to the presence of a minute parasitic fungus—*Exoascus deformans*—one of the simpler of the sac fungi—(Ascomyceteae). The fungus attacks the parenchyma of the leaves and twigs, enlarging, thickening, curling and distorting them. Eventually the leaves become yellowish and fall off, involving as a consequence the wilting and dropping of the fruit. It has been estimated that the annual loss in the United States from this source alone amounts to between two and three millions of dollars.

Mr. Pierce's paper discusses not only the structure of the fungus and the nature of the disease, but includes records of the many experiments which he made in order to determine what are the most efficient means for preventing or combating the disease in the orchard. He recommends spraying with Bordeaux Mixture of the following proportions: Copper sulphate, five pounds; lime, five pounds; water, forty-five gallons; applying it with what is known as a 'Cyclone Nozzle,' and doing the work from one to three weeks before the opening of the blossoms in the spring.

A NEW BOTANICAL JOURNAL.

MR. A. A. HELLER, the well-known botanical collector of Lancaster, Pa., has issued the first number of a new botanical journal bearing the euphonious name of *Muhlenbergia*. This first number is an eight-page octavo, well printed, on good paper. The prefatory editorial statement indicates that it is to be somewhat like Professor E. L. Greene's *Pittonia*, appearing, like that journal, at irregular intervals, and serving largely as the personal organ of its editor. The present number is devoted entirely to 'Some Changes in Nomenclature,' in continuation of the first pages of the 'Catalogue of North American Plants,' recently issued by the same author. Other numbers are promised to appear 'at early dates,' and they are to contain 'articles of general interest, both technical and non-technical, treating not only of flowering plants and ferns, but of the lower cryptogams as well.'

ENGLER'S 'PFLANZENREICH.'

THE indefatigable Berlin botanist who has brought one great work—'Die Natürlichen Pflanzenfamilien'—almost to completion, now undertakes a still greater work under the title 'Das Pflanzenreich.' The former treated of the families of plants, and the arrangement and brief characterization of their genera; the latter is to give full descriptions of genera, and diagnoses of all their species. The 'Pflanzenfamilien' was in fact a Genera Plantarum, supplementing, and to some extent supplanting, Bentham and Hooker's 'Genera Plantarum'; the 'Pflanzenreich,' on the other hand, is to be a universal 'Species Plantarum.' It is by all odds the greatest work in systematic botany ever undertaken.

It will be issued in the form of monographs, each family receiving separate treatment. For the present the work will be confined to the *Embryophyta siphonogama* (*Spermatophyta*), but it is the intention of the editor to take up later the *Embryophyta asiphonogama*, and ultimately the *Euthallophyta* and *Myxothallophyta*. The families are numbered, and the monographs will appear as fast as they are completed. The first one to appear is Family 45—Musaceae—from the pen of Dr. Karl Schumann. Its treatment is such as to assure us of the most satisfactory results. In particular are the excellent illustrations to be commended.

CHARLES E. BESSEY.
THE UNIVERSITY OF NEBRASKA.

PRACTICAL RESULTS OBTAINED FROM THE STUDY OF EARTHQUAKES.

FROM observations on the destructive effects of earthquakes, the knowledge obtained respecting the actual nature of earthquake motion, and from experiments made upon brick and other structures, new rules and formulæ for the use of engineers and builders have been established. In Japan and other countries, these have been extensively applied in the construction of piers for bridges, tall chimneys, walls, ordinary dwellings, embankments, reservoirs, etc. Inasmuch as the new types of structures have withstood violent earth shakings, whilst ordinary types in the neighborhood have failed, it may be inferred that much has already been accomplished to minimize the loss of life and property.

The application of seismometry to the working of railways, particularly in Japan, has led to the localization of faults on lines, and alterations in the balancing of locomotives. The result of the latter has been to decrease the consumption of fuel.

Records of the unfelt movements of earthquakes indicate the time, the position, and what is of more importance, also the cause of certain cable interruptions. The practical importance of this latter information, especially to communities who may by cable failures, be suddenly isolated from the rest of the world, is evident. The many occasions that earthquake records have furnished definite information respecting disasters which have taken place in distant countries, correcting and extending telegraphic reports relating to the same, is another indication of the practical utility of seismic observations. Seismograms have frequently appraised us of sea waves and violent earthquakes in districts from which it is impossible to receive telegrams, whilst the absence of such records has frequently indicated that information in newspapers has been without foundation, or at least exaggerated. The

localization of the origins of these world shaking earthquakes, beside indicating the suboceanic sites of geological activity, positions where the hydrographer may expect to find unusual depths. They have also shown routes to be avoided by those who lay cables.

Seismograms of unfelt movements throw light upon what have up to recently been regarded as unaccountable deflections in the photograms from magnetographs, barographs, and other instruments sensible to slight displacements. They have also explained unusual rates in certain time-keepers. The most important scientific result obtained is dependent upon observations on the rate at which motion is propagated in various directions through the world. Until these observations had been made, our knowledge respecting the interior of the earth, chiefly related to its density and temperature, now we know much respecting its rigidity.

JOHN MILNE.

SCIENTIFIC NOTES AND NEWS.

OTTO H. TITTMAN, assistant superintendent of the U. S. Coast and Geodetic Survey, has been promoted to the superintendency, vacant by the resignation of Dr. Henry S. Pritchett, to accept the presidency of the Massachusetts Institute of Technology. Mr. Tittman has been connected with the Survey since 1867.

PROFESSOR JOHN C. SMOCK, for the last ten years geologist of the State of New Jersey, has tendered his resignation.

MR. OUTRAM BANGS has been appointed assistant in mammology in the Museum of Comparative Zoology at Cambridge, Mass.

SIR JOSEPH HOOKER, the eminent English botanist, has been elected a foreign associate of the Paris Academy of Sciences.

LORD LISTER has resigned his position on the Senate of the University of London as representative of King's College, and Dr. Thomas Buzzard has been appointed in his place.

MR. EVELYN B. BALDWIN has sailed for Europe to examine methods of polar exploration, and to secure equipment for the proposed expedition under the auspicies of Mr. Ziegler.

PROFESSOR CARL GEGENBAUR has received the Swammerdam medal of the Amsterdam Society of Medical and Natural Science.

MR. LEROY ANDERSON, who was this year called from Cornell University to the University of California as instructor on dairy husbandry, has been offered the position of chief agriculturist in the Philippines. Mr. Lawrence M. Jacobs, of the Treasury Department, has been appointed statistician of the Taft Philippine Commission.

DR. A. DONALDSON SMITH, after lecturing before the Royal Geographical Society, has returned from England to his home in Philadelphia.

DR. ROBERT T. HILL, of the U. S. Geological Survey, non-resident lecturer to the University of Michigan, is now delivering a series of lectures at that University on 'The Industrial Significance of the West Indies to the United States.'

AN executive committee has undertaken to erect a bust of the late Professor J. B. Carnoy in the cytological laboratory established by him in the University of Louvain. An honorary international committee has been formed, including in America Messrs. Agassiz, Eigenmann, Macallum, McMurrich and Minot.

IT is proposed to found two memorials in honor of the late Miss Mary Kingsley, one a small hospital at Liverpool for the treatment of tropical diseases and one a Society for the study of the natives of West Africa. It is planned "that the 'Mary Kingsley Society' should employ a trained ethnologist, both to collect and arrange in scientific form the material which is thus already on record, and to institute and direct research for further material of the same sort; and it is intended that the Society, after the manner of the Royal Asiatic Society, should periodically publish the results which it obtains and should thus provide additional knowledge by which European relations with West Africa may be most safely and effectively directed, with profit both to the natives and to the Empire."

DR. BURKE AARON HINSDALE, professor of the science and art of teaching at the University of Michigan since 1888 and the author of various

publications on education and history, died on November 29th aged 63 years.

PROFESSOR MARSHAL OLIVER, of the Department of Marine Engineering, U. S. Naval Academy, died on November 26th at the age of 57 years.

PROFESSOR GEORGE FREDERICK ARMSTRONG, professor of engineering at Edinburgh University, died on November 14th. He was born in 1842 and became professor at Edinburgh in 1885.

DR. JOHN COCKLE, who was one of the oldest members of the medical profession in Great Britain, having qualified as a member of the Royal College of Physicians in 1835, died on November 14th. Dr. Cockle was in 1897 president of the Medical Society of London and was the author of various papers on diseases of the heart and of the organs of respiration, on the poison of the cobra, etc.

THE ninth annual meeting of the American Psychological Association will be held at Johns Hopkins University on December 27th, 28th and 29th, under the presidency of Professor Joseph Jastrow.

THE American Physiological Society will hold its thirteenth annual meeting in Baltimore on Thursday and Friday, December 27 and 28, 1900. The usual smoker will be held on Wednesday evening, December 26th. Those who will require apparatus or other necessities for the making of demonstrations may communicate with Professor W. H. Howell, Johns Hopkins University.

DR. ADAM PAULSEN, director of the Meteorological Institute of Copenhagen, has gone to North Finland to study the aurora. He undertook a similar expedition last winter to North Iceland.

MR. MARSHALL H. SAVILLE, of the American Museum of Natural History, sailed from New York, on November 21st, for Mexico, where he will spend some six months exploring the ruins of Mitla.

MR. ALFRED P. MAUDSLAY passed through New York on November 27th, on his way to Oaxaca, Mexico.

MR. WALTER R. HARPER has explored some rock-shelters near Port Hacking, New South Wales, finding stone axes at a depth of five feet. Bone needles were also found in the same deposits.

ACCORDING to Reuter's Agency advices from Laurvig announce that Captain Stökken arrived there on November 20th, and expressed his readiness to take part in the expedition being organized by the Duke of Abruzzi, who is now at Laurvig, to search for the three missing men of the Duke's former expedition, among them being a son of Captain Stökken. The expedition will probably start from Götenborg on board the whaler *Cappella*, which has been chartered by the Duke and will probably reach Franz Josef Land in the middle of July. The island will then be thoroughly searched. The expedition will be composed solely of Norwegians.

WE learn from *Nature* that early in the summer a memorial was submitted to the Governments of South Australia and Victoria praying that facilities might be granted to Mr. Gillen, one of the inspectors of aborigines, and Professor Baldwin Spencer for the continuance of their investigations into the habits and folk-lore of the natives of Central Australia and the Northern Territory. The memorial, which was signed by all British anthropologists and many prominent representatives of other sciences, has met with a prompt and generous response. The Government of South Australia has granted a year's leave of absence to Mr. Gillen, and the Government of Victoria has provided a substitute for Professor Spencer during his absence from Melbourne. Mr. Syme, the proprietor of the Melbourne *Age*, has contributed $5,000 towards the ordinary expenses of the expedition. The Government of South Australia has also allowed the expedition to make use of the depôts and staff of the Transaustralian telegraph for the forwarding and storage of supplies. The explorers start in February, and it may be confidently anticipated that, if the winter rains make conditions favorable for traveling, they will be rewarded with the same conspicuous success which attended their expedition of three years ago; although the task before them requires even greater tact, since the natives of

the Northern Territory are more difficult to deal with than the aborigines of the center, who know Mr. Gillen and regard him with the utmost confidence. The tribes of the MacDonnell Ranges will be studied even more minutely than before, and afterwards the explorers will go towards the Gulf of Carpentaria, along the Roper River, and, time permitting, proceed down the Daly and Victoria Rivers.

According to a despatch from Berlin dated December 1st, the Duc de Loubat has presented to the Berlin Museum of Ethnology a valuable collection of Central American antiquities.

Mr. Frederick Stearns, of Detroit, who gave the Stearns collection of musical instruments to the University of Michigan, has sent word from Europe, where he now is, that he has purchased two hundred more instruments to be added to the collection.

Mr. Richard James Wilkinson, of the Straits Settlements Civil Service, has presented to Cambridge University his entire collection of books in the Malay language amounting to 63 MSS. and about 50 lithographed or printed volumes.

Ex-Governor Pillsbury, of Minnesota, has given 1,000 acres to the State Forestry Board for the purpose of encouraging State forestry reserves in Minnesota and giving the State Board a chance to experiment with cut-over timber tracts, with a view to determining the extent to which the growth of timber can be renewed. Mr. Pillsbury specifies that two-thirds of the revenues which may be derived from his gift must go to the State University at Minneapolis.

At the monthly meeting of the London Zoological Society on November 24th, it was stated that during the months of August, September and October there had been 483 additions made to the Society's collection of living animals, among which special attention was called to two tenrecs (*Centetes ecaudatus*), deposited by the Hon. Walter Rothschild, M.P.; to a Ludwig's bustard (*Eupodotis Ludwigi*) from Port Elizabeth, presented by Mr. J. E. Matcham, and to a bouquet's Amazon (*Chrysotis bouqueti*) from Dominica, West Indies, acquired by purchase, all new to the collection. It was also stated that during the same period there had been 270,578 visitors to the Society's gardens, being an increase of 11,241 as compared with the corresponding period in 1899. The receipts under this head of income consequently showed during this period a substantial increase. The meeting adjourned until December 20th next.

The report of the Austrian Medical Commission of the Vienna Imperial Academy of Science, sent to Bombay, in 1897, to study the plague, states that some animals, including man, may be readily infected when the virulent matter is rubbed on the skin, even though the latter be totally free from any lesions. The report also gives evidence to show that perfect immunity can be given to the most susceptible animals. It will be remembered that the work of the commission was cut short because of the accident resulting in the death of Dr. Müller in 1898.

The Pekin correspondent of the London *Times* cables: "In pursuance of their regrettable policy of appropriation, the French and German generals, with Count von Waldersee's approval, have removed from the wall of Pekin the superb astronomical instruments, erected two centuries ago by the Jesuit fathers. Half of them will go to Berlin and the rest to Paris. The explanation of this act of vandalism is that, inasmuch as the return of the court is so improbable, such beautiful instruments should not be exposed to the possibilities of injury when Pekin is no longer the capital."

The experimental and chemical departments of the research laboratories of the Royal Colleges of Physicians and of Surgeons on Victoria Embankment have been completely reorganized and are now well equipped for the carrying out of research work. During the year a grant of £100 has been voted by the laboratories committee to Mr. W. P. Bloxam, B.Sc., for his work upon the chemistry of antitoxic bodies. A grant of £25 was voted to the director for expenses incurred in his work upon the same subject from the Goldsmiths' Company's research grant. The research grant has also been utilized in supplying antitoxic serum to various general and children's hospitals. The

report gives descriptions of 204 specimens added to the physiological series of the museum, and also of various preparations added to the pathological series. The library contains more than 50,000 volumes, and is being increased at the rate of about 1,000 volumes a year. It is particularly rich in the transactions of societies and in periodicals, relating not only to medicine and surgery, but also to accessory sciences. The library includes a collection of portraits of members of the medical profession.

WE learn from *Nature* that a private conference was recently held at the Board of Trade to consider the protection of the delicate instruments in use at Kew and Greenwich Observatories from magnetic disturbance, through the working of tramways and railways in the metropolis by electricity. Sir Courtenay Boyle presided, and among the officials of the Board of Trade present were Mr. F. J. S. Hopwood, Sir Thomas Blomfield and Mr. Trotter. The observatories and kindred public departments were represented by Mr. Christie (the Astronomer-Royal), Professor Rücker, Mr. Glazebrook (Director of the National Physical Laboratory), Lieutenant-Colonel Raban (Director of Works at the Admiralty), Admiral Sir W. J. Wharton (Hydrographer to the Admiralty), and Professors Ayrton and Perry. Among those who attended as representatives of the railway and tramway interests concerned were Mr. George White (chairman) and Mr. J. C. Robinson (engineer) of the London United Tramways Company, Sir Benjamin Baker and Sir W. Preece.

MR. E. C. OLIVER of the mechanical engineering department of the University of Illinois, has succeeded, with the advice of Professor Breckenridge, in perfecting an automatic recording machine which records automatically different data with regard to the speed and power of engines. The recorder can be applied to either gas or steam engines or to a dynamometer car, and is capable of taking any, one or all, of eight readings by means of ink pens on an endless roll of paper. The recorder gives faithfully the speed of the engine, the number of the horse power exerted, the rate of the occurrence of the explosions and the number of revolutions per minute of a gas engine.

MR. HUGHES, United States Consul at Coburg, reports that in Coburg and neighboring parts of Germany considerable attention is being paid to electrical appliances that can be used on the farm. Near Ochsenfurt, in Bavaria, a company, composed of land owners and small farmers, has been organized for the establishment of an electrical system for use on their farms and in villages. The power is to be generated by steam and water and the current to be distributed from a central station to the places at which it is wanted. Sub-stations are to be established at given points, with the necessary apparatus for connecting with the farm or other machinery and also for lighting purposes in the houses, offices, roads and village streets.

THE Dutch cabinet submitted to the States General, on November 14th, a new bill proposing to drain the entire Zuyder Zee.

THE field work of the Division of Forestry of the Department of Agriculture, which has been carried on in many parts of the country by parties of different sizes since last May, has now been largely completed for 1900. This summer's work was carried on in New York, Tennessee, Missouri, Colorado, South Dakota, Arkansas, Arizona, Washington, Oregon, California, a number of tree-planting States of the Middle West and, in a small way, in other States besides. Much new and valuable information has been collected, and a very large number of surveys has been made, of the results of which it will soon be possible to make practical use. The work which has thus been going on in the field consisted of making forest surveys and of gathering measurements and information about growth, stand, reproduction, etc. Much of it, as that in the Black Hills Forest Reserve, in the Adirondacks, and on the tract of the Sawyer & Austin Lumber Company in Arkansas, is preparatory to the preparation of what are called 'working plans,' or plans for the management and utilization of given tracts of timber. These are based not on any general rules, but on a thorough knowledge of the peculiarities of the forest on each tract, of the market and transportation facilities of the regions in which they are situated, and of the

financial necessities of each case. The rest of the work of the field parties has been more of the character of investigations—as, for instance, the examination of the influence of forest cover on waterflow which was made on the watershed of the Arrowhead river in southern California, the studies of the habits of growth and reproduction of the two most important lumber trees of the Pacific coast—the Red Fir and the Redwood, and the survey of the results of tree-planting undertakings which have been carried on in the northern part of the Mississippi Valley. During the coming winter the agents of the Division will spend most of their time in working up the results of the summer's surveys and in preparing reports on them, although there will doubtless be some field work as well.

THE total exports from the United States during the month of October, as shown by the records of the Treasury Bureau of Statistics, were $163,093,597. The total for ten months ending with October, 1900, is $1,194,775,205, or practically double that of the ten months ending with October, 1894. Exports exceeded imports during the ten months ending with October by $499,667,936, while in the corresponding ten months of 1894 imports exceeded exports by $96,663,369. The exports of last month were far in excess of any previous month, exceeding those of March of the present year, which hitherto had the highest record, by nearly $30,000,000.

UNIVERSITY AND EDUCATIONAL NEWS.

YALE UNIVERSITY has received $68,152 from the estate of the late John De Kovey.

IN an address to the students of Colorado College, Dr. D. K. Pearsons, of Chicago, announced that on January 1, 1901, he would make the college a gift of $50,000 toward the cost of completing the new scientific building now in course of construction.

UNDER the will of the late Dr. D. J. Leech, professor of materia medica and therapeutics in the Owens College, Manchester, that college will eventually receive £10,000, for endowing a chair of materia medica and therapeutics.

THE University of Wisconsin has received $1,000 from Charles F. Pfister and a like amount from Fred Vogel, both of Milwaukee, to be expended in the purchase of books for the School of Commerce.

THE Yale University treasurer has bought an additional piece of property on Cedar Street in New Heaven, by which, with earlier purchases, a continuous front of about 200 feet opposite the New Haven Hospital is secured for a new site for the Medical School, at a total cost of about $60,000.

DR. DE WILDE, minister from the Argentine Republic, is interested in the establishment of ten agricultural and mechanical colleges in that country after American models. To this end there are twenty-eight students of the Republic now attending colleges in this country, both in the East and the West.

IN a letter to the *Times* Mr. T. Clifford Albutt states that in spite of constant efforts during the last two years the Chancellor of Cambridge University has received no more than £62,500, one half of which amount comes from the Chancellor himself, Lord Rothschild and Mr. Astor. "These funds are now being expended on the laboratories and museums of geology, botany, and pathology, which are most needed; but they will not meet the cost even of these; the botanical and pathological departments alone will cost more. Again, among the offices still vacant here for lack of funds are twenty-three of the readerships prescribed by the Commission as necessary. The normal salary of a reader is £400 a year; I should be surprised to hear that the average income of our present readers is more than £200. Our revenue on paper seems large no doubt, but the bulk of it is in trust for specific purposes, some of which are and some are not of paramount importance; every penny, however, that could be set free for development was so freed by the Royal Commission. * * * Unless the public by donation or bequest be more generous, we can hardly hope to keep in the van of modern education; yet for Oxford and Cambridge to fall back would be a national misfortune."

J. SHIRELY EATON, the statistician of the Lehigh Valley Railroad, has been elected to a chair of domestic commerce and transportation at New York University.